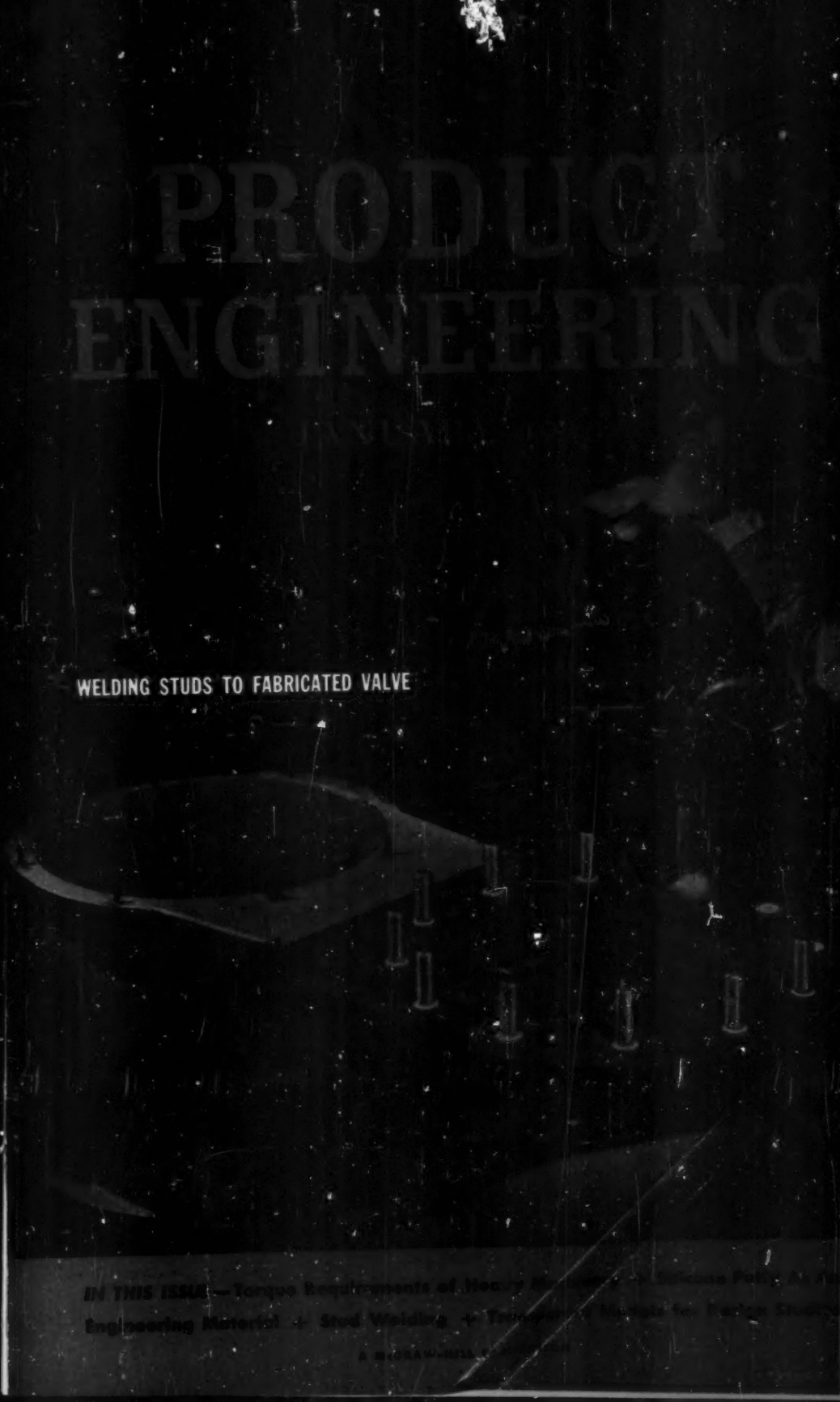
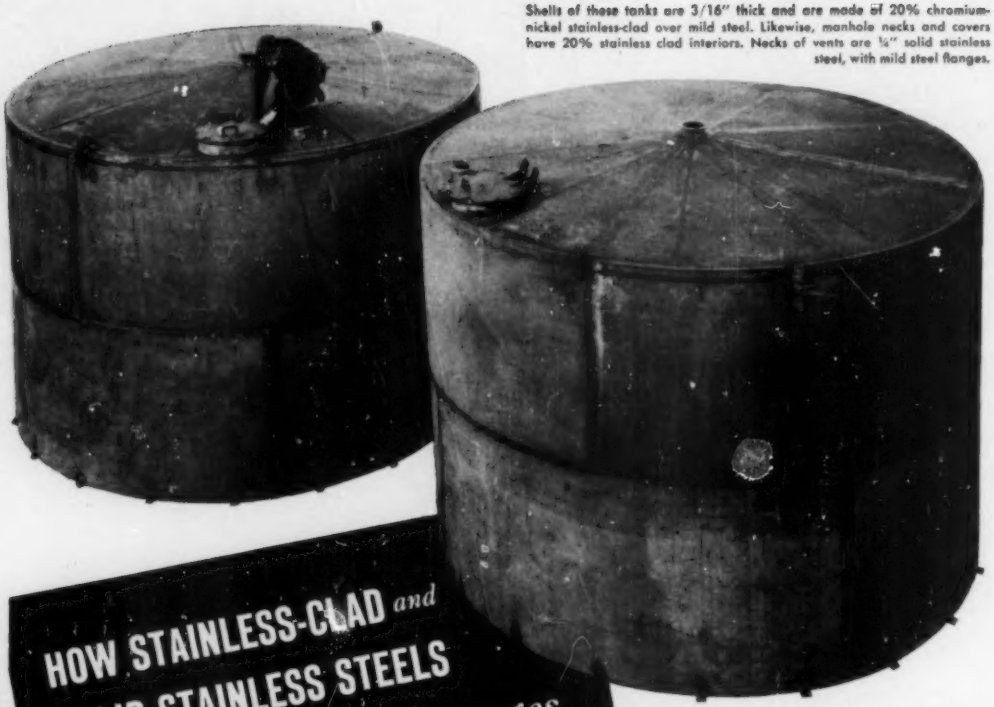
PRODUCT ENGINEERING



WELDING STUDS TO FABRICATED VALVE

IN THIS ISSUE—Torque Requirements of Heavy [illegible] Engineering Material + Stud Welding + [illegible]

Shells of these tanks are 3/16" thick and are made of 20% chromium-nickel stainless-clad over mild steel. Likewise, manhole necks and covers have 20% stainless clad interiors. Necks of vents are ¼" solid stainless steel, with mild steel flanges.



HOW STAINLESS-CLAD *and* SOLID STAINLESS STEELS *Provide Vital Advantages for Beverage Storage*

This interior view of a hoisted tank shows the solid stainless steel angles used for top bracing.

Complex needs of the beverage processing industries have led to the use of several different chromium-nickel stainless steels to solve specific corrosion problems...

But corrosion resistance is only one of the many virtues of austenitic chromium-nickel stainless steels.

In addition, they are readily fabricated, may be welded with ease and are highly resistant to impact and wear. Parts made of these stainless steels are easy to clean and keep clean.

Charles T. Brandt, Inc., of Baltimore, Md., constructed the two 25,000-gallon storage tanks shown here of Type 304 stainless-clad and solid stainless. The tanks are adequately strong, are corrosion resistant, and do not contaminate the stored syrup.

Leading steel companies produce chromium-nickel stainless steels in all forms such as sheet, strip, bars and tubes. A list of sources of supply will be furnished on request.

Choice of the correct type for your application assures longer service life, fewer repairs and minimum maintenance.

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

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VOLUME 21 — PRODUCT ENGINEERING — NUMBER 1

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JANUARY 1950

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If the problem is to fasten a stud to an assembly, why not use stud welding.

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FRONT COVER — Hand welding studs to a fabricated vent valve approximately three feet long and a foot and a half high at the Johnston and Jennings Company, Cleveland, Ohio. Kodachrome courtesy of Nelson Stud Welding Div. of Morton-Gregory Corp.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

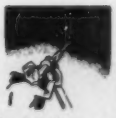
SIMPLE ANSWER to preventing corrosion of ship hulls is to hang magnesium plates in the water next to the steel ship. Primary cells are formed – magnesium is the anode, steel the cathode, water the electrolyte. Slight decomposition of the water film next to the hull arrests corrosion.

TWO HUNDRED POUNDS of uranium will soon be on tap for industrial experimentation. Purchase of the silver-colored metal is via the Atomic Energy Commission who license sales at about $50 per pound. Rods of the ductile material will not be pure enough for application to nuclear reactors.

YIELD STRENGTHS, both in tension and compression, are nearly equal for an improved magnesium extrusion alloy containing 6 percent zinc and 0.6 percent zirconium. Toughness, notch insensitivity and light weight make the material applicable to airplane, truck and trailer structures, textile machinery and materials handling equipment.

OPAQUE ALLOY of germanium and silicon has promise for infrared testing equipment as a lens material that will transmit invisible heat radiations. Alloy is not subject to moisture attack and is sufficiently hard to permit grinding to precise dimensions, both improvements over previously used rock salt.

TRACER BULLETS and cigarette lighter flints may soon be made from rare earth metals uncovered in California. Deposits are a fluorocarbonate of cerium and lanthanum combined with thorium and uranium. Similar material of extreme purity, but in limited amounts, has been artificially produced at high cost in atomic piles or imported from Brazil or India.



ATOMIC LITHIUM in a magnesium-rich alloy has possibilities as a super-lightweight, ductile metal, according to a UN report.

PREMATURE FAILURE of zinc-plated steel water tanks can be explained by a reversal of potential that makes the zinc cathodic to the steel. The loss of corrosion protection is caused by oxygen trapped in the system.

Nonmetallic Materials

THE FLUORINE PLASTIC, Teflon, has a greatly broadened field of application now that it can be reduced to fine particles and suspended in a liquid. Sprayed on metal, it prevents corrosion; extruded on wire, it serves as an insulator.

ARCTIC WEATHER down to -75 F does not phase a new synthetic rubber polymer – instead of shattering on impact, it bounces. Material may be the answer for tires, hose, belting and gaskets that usually freeze solid when the thermometer hits sixty below.

NON-POROUS PAINT hardens immediately after spray application to form a protective coating having three times the life of existing finishes. Waxy mass of resins and oils is melted in the gun and sprayed through an acetylene flame onto a metal surface. If coating becomes chipped, rust that forms on the bared metal does not extend radially under the adjacent paint.

THERMOSETTING ADHESIVE containing no volatile solvent permanently bonds metals, glass, ceramics, plastics, wood and other rigid materials to themselves or to each other. No shrinkage or swelling occurs after curing at 200 F for two hours. One application is for bonding aluminum alloy spacers to steel disks in magnetic fluid clutches.

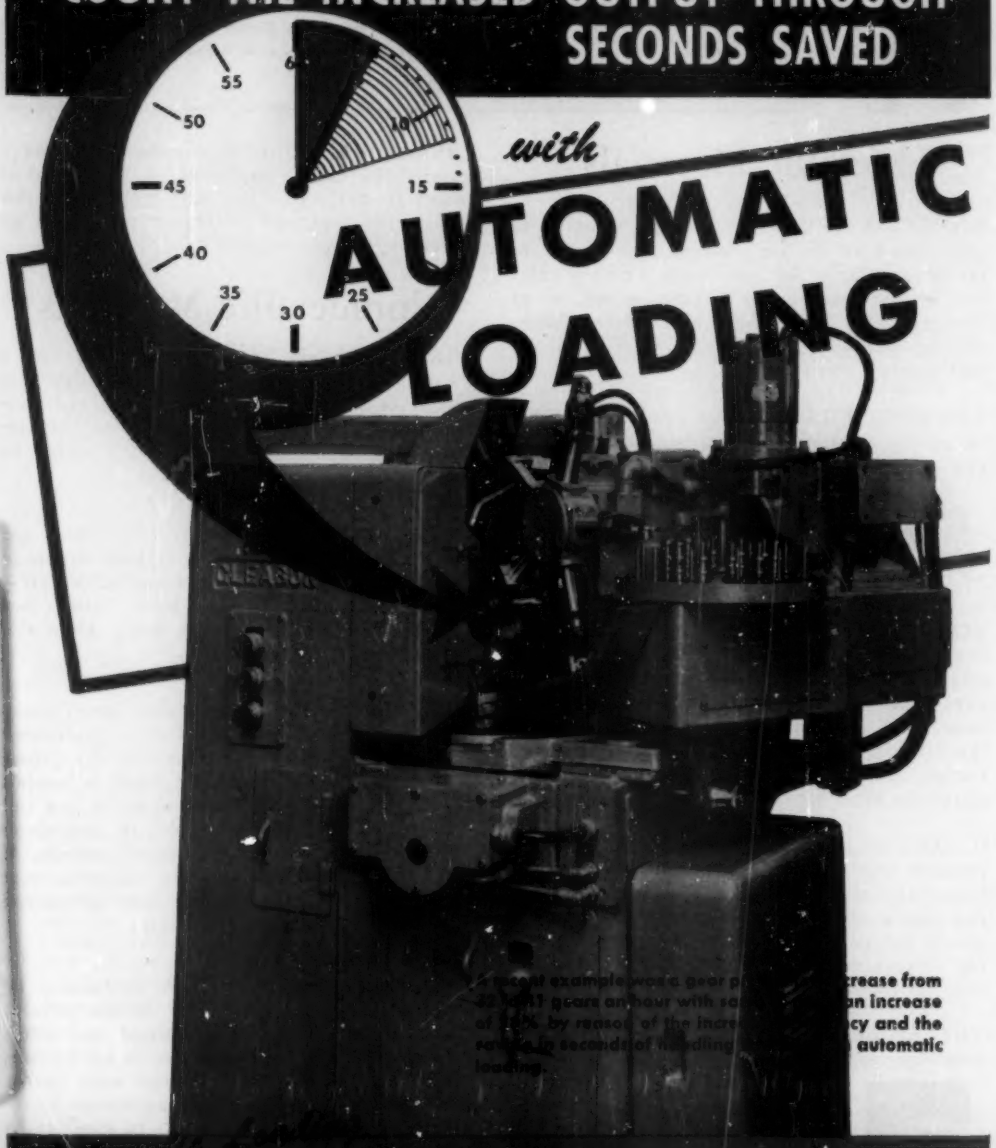
PAPER AND CLOTH for use in Ozalid-type white-print machines have plastic surfaces that produce sharp, clear reproductions of line drawings. Black or sepia lines are "sealed" into the surface, permitting cleaning with a damp cloth, yet alterations are no problem if

Continued on Page 5

COUNT THE INCREASED OUTPUT THROUGH SECONDS SAVED

with

AUTOMATIC LOADING



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lines or figures must be added or removed. Surface coating also prevents the sheets from becoming brittle and yellow with age.

Processes

WELDING IN REVERSE has simplified fabrication of harrow teeth for farm equipment. A 12-in. steel bar is gripped in welder terminals and current applied. When the area between terminals is red hot, an air cylinder pulls the terminal jaws apart, forming two narrow points. No further operations need be performed.

PREPOLISHING SHEET STEEL before forming is now practical. Shine up the flat stock, spray a lacquer solution over the surface, form the part and then remove the lacquer with a blast of air. Only time process won't work is when part is to be forged – the lacquer will not protect finish against damage from the forging hammer.

A WATER FOG at 500 psi is the Army's latest method of extinguishing a gasoline "spill" fire. The Job takes just 13 seconds.

BEARING FAILURES in turbines operating at high speeds and excessive temperatures often occur in the yellow-brass separators, not in the rollers or races. By silverplating the brass, life of the bearing can be appreciably prolonged. Such parts will function for several hours without lubrication before failure actually occurs.

VITREOUS ENAMEL fired to aluminum sheet and castings is not as "hot" a job as with steel. Firing temperature on steel is 1,400 to 1,600 F; on aluminum alloys it's only 970 F. Coated aluminum can be flexed or subjected to severe impact without danger of cracking the finish.

SPHERICAL SHOT can be formed by passing molten lead through perforated sheet metal. Tear-drop shapes are avoided if pouring is done in a butane oxide-reducing atmosphere.

BI-METALLIC PARTS like cast-iron-banded aluminum pistons are growing in popularity. Application to timing gears, aluminum-steel bearing housings, aluminum-finned brake drums is resulting in 50 percent more heat dissipation and 25 percent less weight.

ONLY TWO of the customary seven steps are necessary in processing lithographic plates by a new method. These are exposure to a negative and gumming – no cleaning, coating, developing, washing or etching. Chemically coated cellulose acetate film in a vacuum frame is exposed to a 30-amp arc lamp for about 25 sec. Unexposed coating on the film is removed during gumming, leaving the "plate" ready for insertion on the press.

Components

SAFETY PURIFIER for combustion engine exhaust systems is choosy about when it absorbs harmful gases and vapors. Only during decelerating or idling periods – when combustion is apt to be incomplete – is the engine's exhaust routed through the filter.

THREE CONCENTRIC CELLS within a single cylindrical rubber or glass casing form a new acid-type storage battery. Similar in most respects to the common rectangular unit, the circular construction has the advantage of less weight, better resistance to breakage and lower fabrication costs.

FLUID MAGNETIC CLUTCHES for controlling, positioning and driving servomechanisms have torque ratings from 4 oz-in. for 1/100 hp drives and 3 lb-ft for 1/4-hp. Small unit accelerates to 6,000 rpm in 0.012 sec; same size servo motor takes 0.27 second.

FUEL PREHEATER for cars insures quick starting at –20 F. Battery-heated nichrome element vaporizes fuel as it enters cylinder.

TIMING MARKS every thousandth of a second can be made on 3,000-frame-per-sec camera film, thanks to a microsecond pulse generator assembly. Neon lamps in six cameras flash simultaneously when wired into the device.

AUTOMATIC CONTROLS for a bank of six elevators do an almost-human job of adjusting traffic to the demands. A robot timer starts cars up or down at intervals from 20 to 40 sec, while an electronic counter keeps track of calls and switches cars from upper floor duty to lower floor service or vice versa as needed. System even shuts off power to one or more cars during "off" hours.

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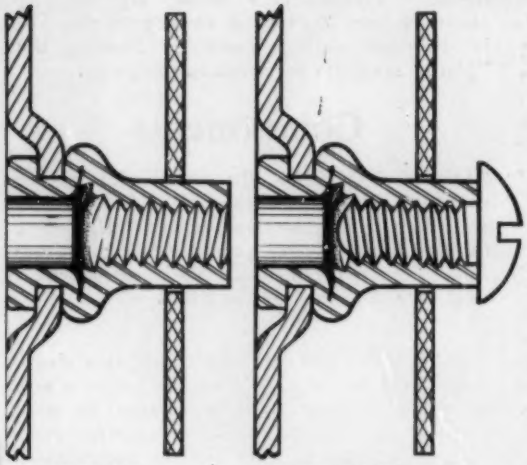
RIVNUTS improve design, cut assembly costs in new lighting fixture



RIVNUT USED AS A LATCH

RIVNUT USED AS A HINGE

Pittsburgh Reflector Company uses Rivnuts as both hinge and latch in "Monroe" fluorescent luminaire

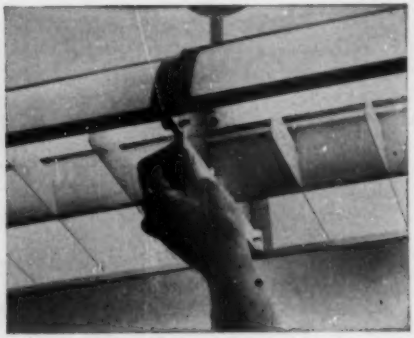
Designers of the new "Monroe" fluorescent luminaire were looking for a fastener that would serve as both hinge and latch to attach the "egg crate" type light shield. They found the perfect answer in Rivnuts—the only one-piece blind rivet with threads.

Two $\frac{7}{16}$ in. Rivnuts are inserted in the 20-gauge steel end panels and upset with an easy-to-use heading tool. The bulge formed in the Rivnut grips the panel tightly. At least 6 threads remain clean to take an attachment screw.

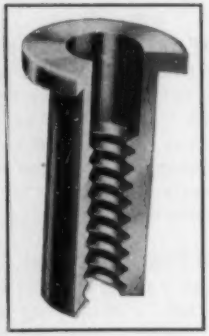
The Rivnuts provide a neat, strong, easy-to-operate hinge and latch combination. And many man-hours of assembly time are saved by the speed and ease of Rivnut installation.

Chances are Rivnuts can solve your fastening problems, too. Get the help of Rivnut engineers. Write *The B. F. Goodrich Company, Dept. PE-10, Akron, O.*

One man installs Rivnut in about two seconds. It aligns itself positively. Flat head fits flush. Does not mar finish.



"Egg crate" louver has spring steel members on each end that hinge and latch to Rivnuts. Opens in one simple operation (no tools) for easy maintenance.



Rivnut can serve as either hinge (with attachment screw) or latch.

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MINIATURE TUBE automatically turns current "on" and "off" 45 million times. Cold-cathode triode consumes no standby power, making it useful in burglar alarms, remote-control devices and automatic business machines.

Products

TWIN TURBINES of the axial flow type placed side by side form a 5,500-hp powerplant for driving coaxial propellers. Developed under Navy contract by Allison, new engine is about half as long as the current J-35 turbojet, yet its weight per horsepower and fuel consumption figures are markedly lower than those of the recently publicized turboprop powerplants in British commercial planes.

X-RAY MACHINE delivers voltages throughout wide range from 100,000 to 250,000. High intensity results from a beryllium "window" in the tube that emits nearly twice as many roentgen or radiation units per minute than do current model tubes.

ALCOHOL BLOW TORCH spouts a 2,700-F flame that tops other designs in its class by 500 F. Silver soldering, brazing and sweat fitting, in addition to soft soldering operations, are therefore within the realm of this single unit. Gun-grip handle eases manipulation and special burner insures uniform temperature and pressure in all positions.

15-LB TELETYPEWRITER for aircraft automatically sends and receives data. Magnesium case is pressurized for use at 50,000 feet.

DISPLAY PRINTING is speeded and costs reduced with a machine that automatically sets and prints an impression in 30 sec. Operated like a typewriter, the Printasign contains 217 cast slugs; handles six sizes of type varying from 1/8 to 2 in. deep.

STRATEGIC LAMINATING is the key to assembling a 29-lb flame resistant suit worn by plane-crash fire fighters. Eighteen layers include four types of glass fiber, nylon, honeycombed cotton cloth, silver and aluminum foil. When stacked in proper sequence, they provide abrasion and heat resistance on the outside, then gas and liquid tightness and finally heat insulation. Body temperature within this ½-in. shell is still comfortable after ten minutes' exposure to a 2,000-F flame. Temperature stays at a cool 130 F after 1½ min in a 2,400-F inferno.

COLD-CATHODE fluorescent lamp has a life of 15,000 hr, a 50 percent increase over existing models. Wire-type electron generator, which slowly deteriorates, is replaced with a metal thimble device that does not lose its effectiveness with continued starting.

Testing

AN ELECTRIC ARC generated between a copper cylinder and a surrounding copper ring creates an air flow many times the speed of sound. A magnetic field moving around the ring spins the arc like the spoke of a wheel; the arc, in turn, causes the air in this "ionic tunnel" to revolve.

ELECTRICAL RESISTIVITY of many materials such as copper and aluminum is practically nil at temperatures approaching absolute zero. If this "super conductivity" characteristic could be commercially applied, energy losses in electric generators and motors could be greatly reduced.

NUCLEAR RADIATION can be detected by measuring the electric charge that will flow through potassium bromide crystals. Normally non-conductors, these crystals are made to take a charge when exposed to gamma rays in a special light. Method has promise in studies where isotopes are used as tracers.

PULSE-LENGTH SORTER counts drops of liquids shot from injector nozzles and aids in studies of spray characteristics.

FUEL ECONOMY of 54 mpg at 20 mph! Here's what you do to a car: use 110-psi tires with a ¼-in. tread in the center, step up compression ratio to 10:1, put SAE 10 oil in the transmission and differential, and SAE 30 oil in the wheel bearings; disconnect generator, fan and water pumps; and use medium-cold spark plugs, a heavy duty coil and a special wiring harness.

ONE WAY to produce a jet-propelled ship is to substitute a multi-throw plunger or rotary pump for the propeller. Then add special nozzles to produce a water jet. Pump supplies pressure head; nozzles provide velocity head.

What a Cold, Calculating Beating this Lug takes!
IT'S NEW! IT'S DIFFERENT! IT'S MADE OF REVERE COPPER —The "Double G" Solderless Lug made by THE GREGORY MANUFACTURING CO., INC., New Haven, Conn., for the electrical field, comes in 6 sizes to accommodate from 14 ga wire to 1,000,000 CM cables. Pressure screws are steel.
HOLD 'EM TIGHT—These sharp, deep-cut serrations on inside of both tubular sections and projection tang help to make firm, non-slip joints possible. They also increase the rigidity and conductivity of the connection. Note that these serrations were made cold, and without any distortion of the Revere Copper used. Lugs shown are twice actual size and are unretouched.
...and not a Scar to show for it!

Improved solderless lug of hard drawn Revere Copper, cold worked over and over without distortion, cracking, pitting or scarring.

Pierced, formed at short 45 degree and 90 degree angles and deeply serrated, this "Double G" solderless lug really gets a working over . . . and cold, too, no annealing. Yet, with all this, the surface remains absolutely smooth, the lug is not in any way weakened and there is no twisting, pitting, cracking or scarring of any kind. And, in addition, its dimensions are held.

When the Gregory Manufacturing Co., Inc., was developing this solderless lug, with its unusual features, it had a problem on its hands.

Their design called for copper strip that could stand a lot of cold working and when finally fabricated into a product of uniform quality, would not have a lot of twist, cracks, pitted or scarred surface. In their efforts to secure such a product their engineers had frequent consultations with Revere's Technical Advisory Service. The result was the product shown and described above, with production time and money saved and rejects held to the vanishing point. The material used was Revere hard drawn copper strip with a temper of 36 to 46 Rockwell B Scale. This company feels that they could not have developed such a successful product if the quality of the copper was not of the best and did not possess the inherent working characteristics needed.

Perhaps Revere Copper or some other Revere Metal can be of help in developing or improving your product—cutting your production costs. Why not tell Revere's Technical Advisory Service about your metal problems? Call the Revere Sales Office nearest you today.

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This unique device furnishes positive power transmission through a chain which automatically forms its own teeth, assuring transmission of every r.p.m. without the possibility of slip or wasted power.

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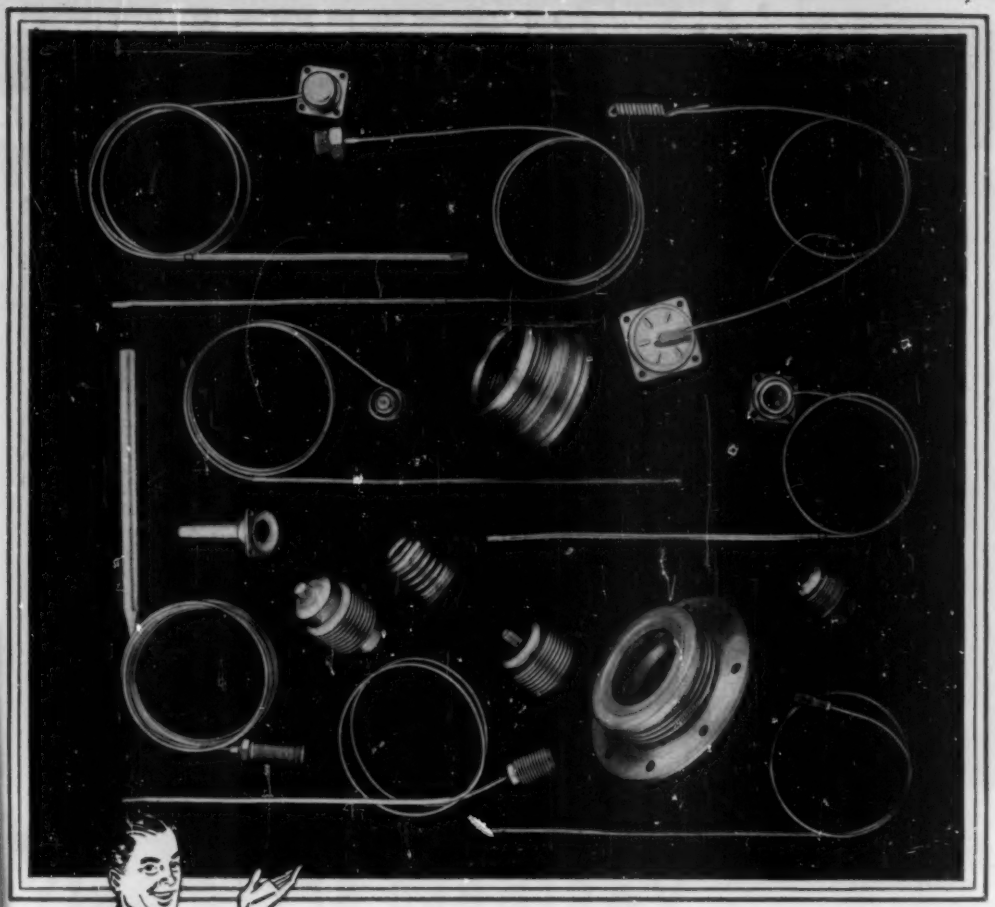
Worm Gear Drives	Ball Bearings
Herringbone Gear Drives	Roller Bearings
Helical Gear Drives	Babbitted Bearings
Gearmotors	Couplings, Clutches, Collars, etc.



Each of these

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If you merely suspect that a bellows assembly can do your job, you're in the same position where some of our most satisfied customers started. Our engineering department will be glad to analyze *your* problem, too. Send *your* sketches and specifications for confidential study and recommendations. There is no obligation.

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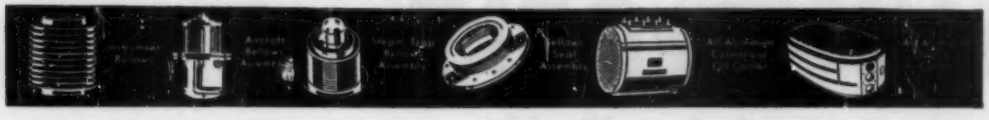
First with the Facts on Hydraulically-Formed Bellows

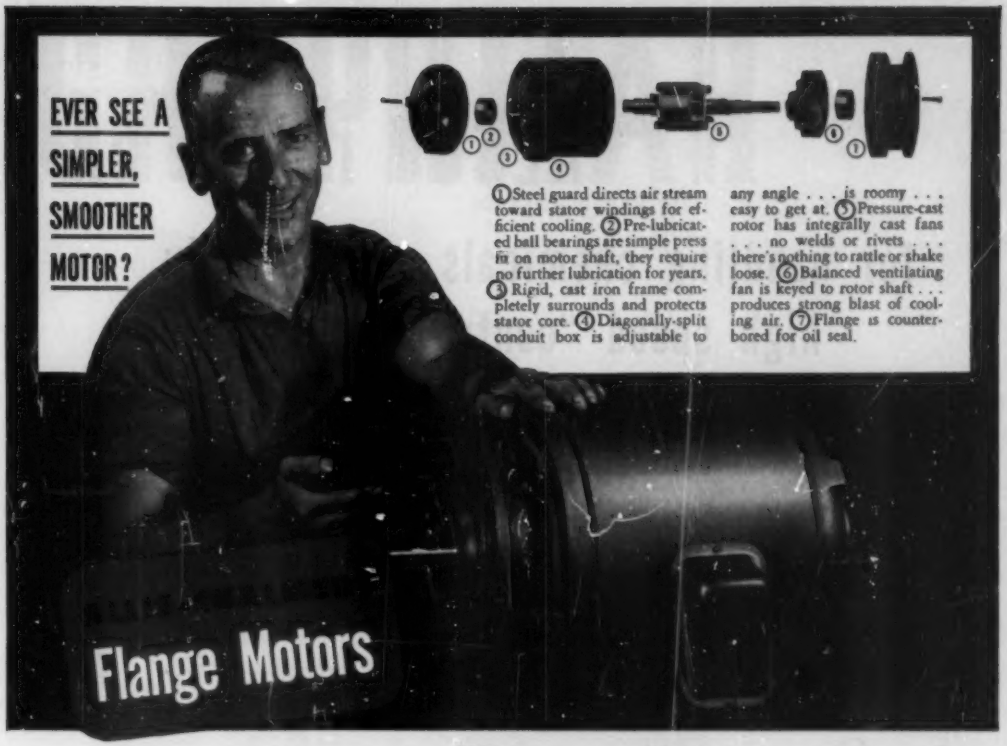
CLIFFORD

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

HYDRON

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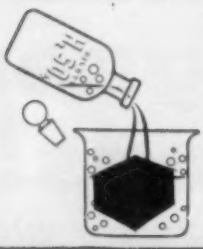

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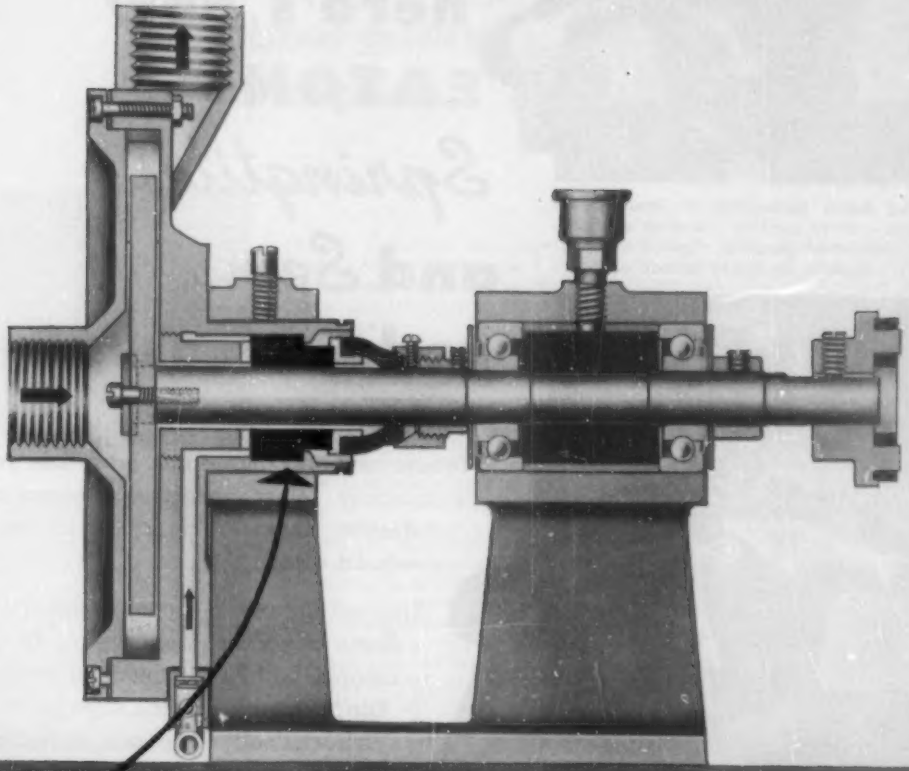

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Springtites

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EATON MANUFACTURING COMPANY

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How to keep a rubber gasket in its place

FIG. 1

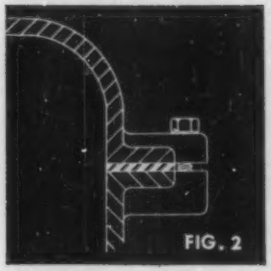
FIG. 2

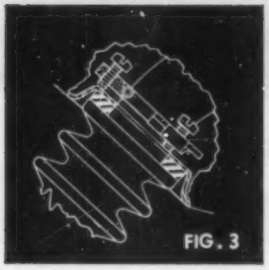
FIG. 3

Because rubber is noncompressible, straight rubber gaskets tend to flow out of place when subjected to flange pressure or the swelling action of oils and solvents.

To keep rubber gaskets in position, truly compressible cork particles are added to the noncompressible rubber. The resulting material compresses on itself, actually decreasing in volume. By varying the amount of cork, a range of compressibilities is provided as in Armstrong's Cork-and-Rubber. When lateral flow is eliminated, gaskets stay in place.

Fully as important as controlled flow are imperviousness and solvent resistance. In Armstrong's Cork-and-Rubber, cork particles are enveloped by a continuous matrix of synthetic rubber. Consequently, cork-and-rubber possesses the resistance to fluid penetration and solvents of a comparable straight synthetic rubber.

In figure 1, for example, cork-and-rubber replaced a straight rubber gasket when straight rubber tended to creep out of place and slip into the tank. Cork-and-rubber conforms to the rolled edge and surface irregularities in the stamped cover without slipping. Hence it provides a dependable pressure-tight seal.

Figure 2 shows the flange of an oil-filled water-immersed switch. Even when exposed to both liquids and the heavy flange pressures, truly compressible cork-and-rubber gaskets seal without creep.

In addition to sealing the transformer bushing shown in figure 3, cork-and-rubber cushions it against breakage. Even on oily flanges, creep is retarded by the surface friction of the exposed cork particles.

Versatile cork-and-rubber has solved many sealing problems. We suggest that you discuss your application with an Armstrong representative. He can help you select the right material for your particular application.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

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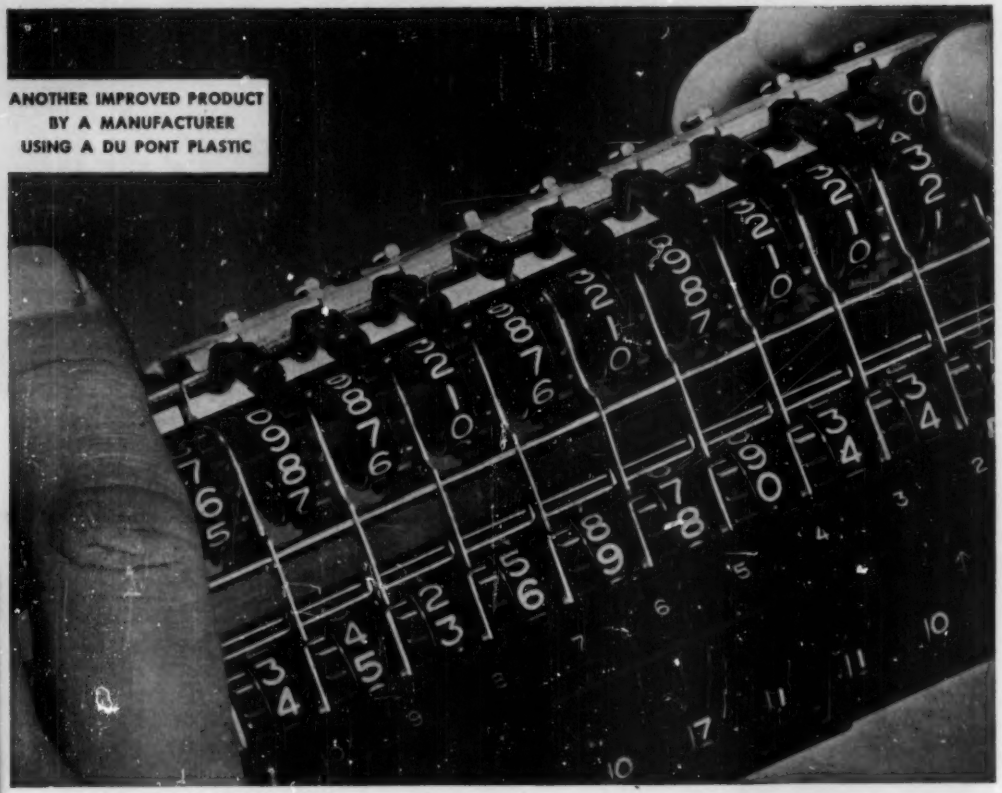

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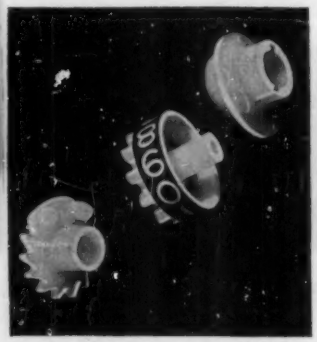
29 production steps eliminated in making two extra-durable parts to tolerances as close as 0.0015 inch!



NEW NYLON RATCHET, counting dial (one of ten) and cam. Molding of cam saved 19 production steps, of the dials —10 steps. Ratchet is new part, only possible with nylon. Note intricate design, molded to close tolerances.

Here's an excellent example of wedding product-improvement to cost-cutting. Monroe Calculating Machine Company, by using Du Pont nylon plastic for counting dials and cams on their calculating machines, gets more durable service from these parts—and through savings in material and operations, cuts costs of the completed parts by 67%. Production steps are cut from 33 for former metal parts to only *four* for nylon. A third part, a new ratchet, is of an improved design so intricate it is possible only with nylon.

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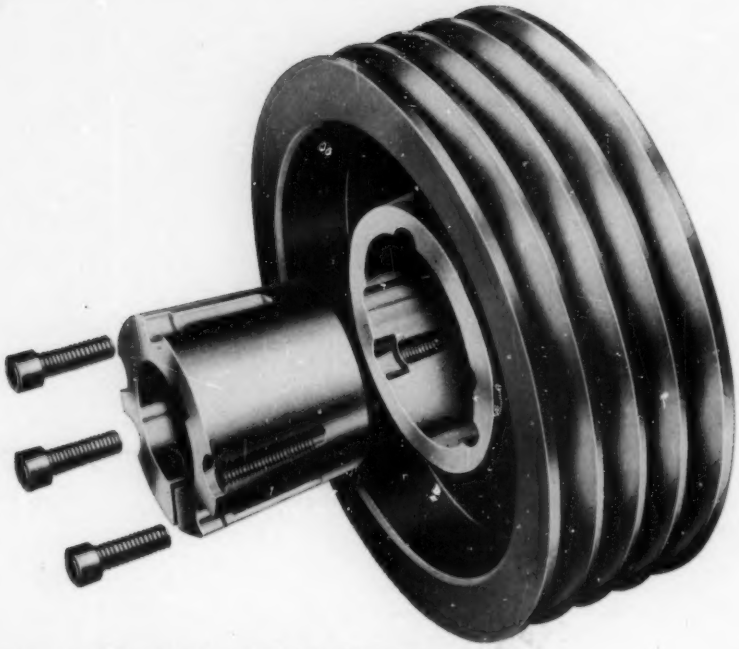

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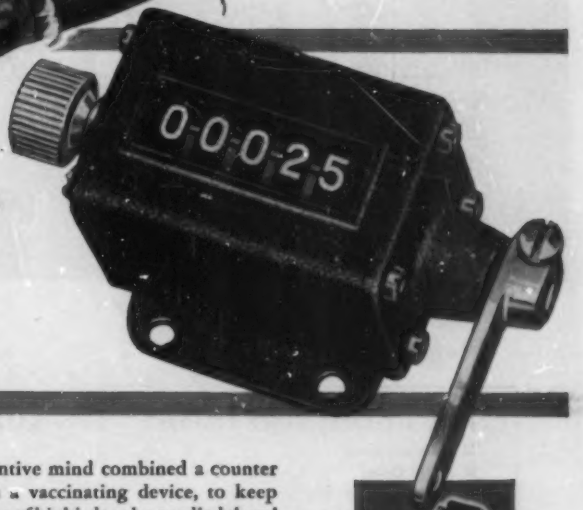
Why does he Count his chickens ...before they are "vaxed"?



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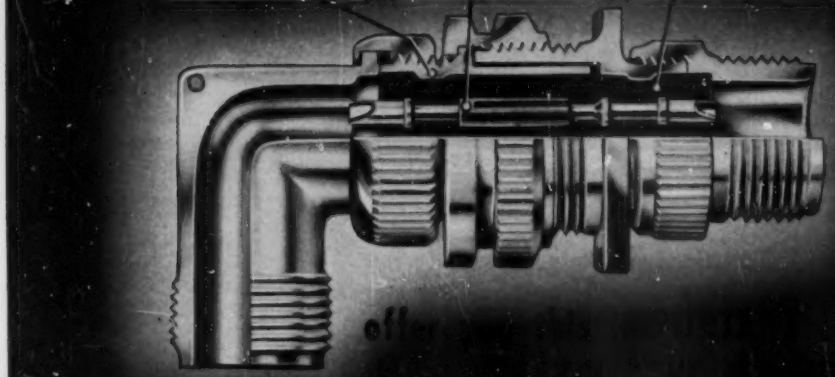
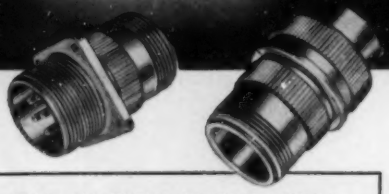
High dielectric strength . . . High insulation resistance.





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- Fewer Parts than any other Connector
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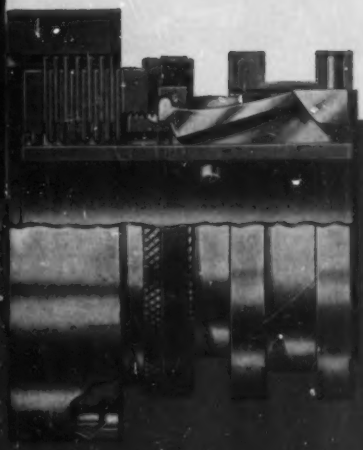

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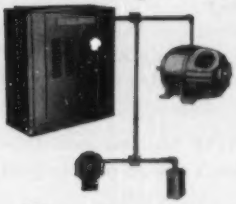

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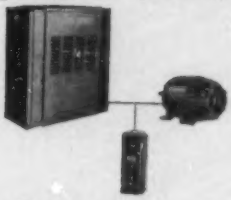

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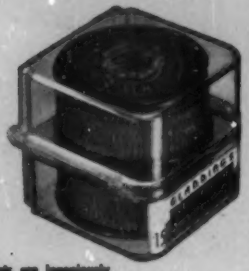

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Two pins on cover are precisely molded to fit into corresponding holes—holding two boxes together when folded.

Styron permits precise molding of hinges that snap together securely without metal parts. Two boxes are easily separated at hinges into half-sided units.

Excellent dimensional stability of Styron gives this box a tight-fitting, sliding cover that maintains close tolerances.

Five Line Box molded by Westplex Corporation, Rochester, New York for S. F. Gladding & Co., Inc., South Otselic, New York.

Let the expert designing know-how of the custom molder solve your difficult fabrication problems quickly and economically. His judicious selection of the right plastic from a wide range of Styron (Dow polystyrene) formulations will give you more pieces per dollar spent.

Extensive design and engineering facilities are maintained by the custom molder to serve you competently. Staffed by technicians with long experience in plastics engineering, these facilities furnish you with first-hand information on the properties and performance of various plastic materials.

Close technical cooperation between The Dow Chemical Company and Custom Molders helps you to utilize Dow plastics to the best advantage in your products. Write Dow today and let us put you in touch with a qualified custom molder, who can solve your problem.

Plastics Division, Dept. SOT-3

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DOW plastics

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The features you get with Mayari R

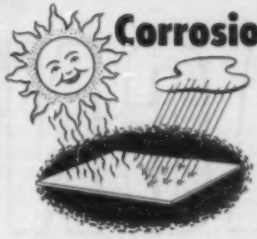
This versatile high-strength, low-alloy steel is helping to improve the designs of a great variety of products including railroad cars, motor vehicles, industrial equipment, fabricated structures and household items. For full information on the properties and applications of Mayari R write for a copy of Catalog 259.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

BETHLEHEM STEEL

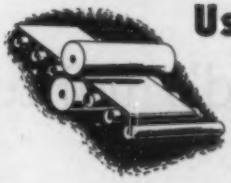
High strength

The 50,000 psi minimum yield point of Mayari R is approximately double that of plain carbon steel, permitting higher working stresses.



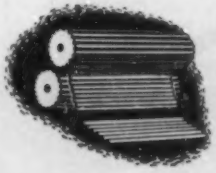
Corrosion-resistance

The atmospheric corrosion-resistance of Mayari R is 5 to 6 times that of plain carbon steel and 2 to 4 times that of copper-bearing steel.



Used as-rolled

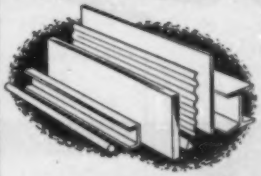
It has advantages of alloy steel without the expense of heat-treatment. Mayari R can be worked hot or cold in the as-rolled condition.



Workability

Mayari R can be formed, sheared, punched, drilled, and welded by the methods used for carbon steel.

Available in many forms



Mayari R is produced in sheets, strip, plates, bars, structural shapes, and cold-formed shapes.

Comparatively low cost

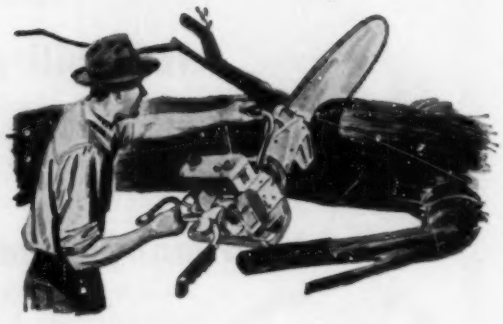
The initial cost of Mayari R is little more than that of carbon steel. This difference is frequently offset by savings in deadweight and maintenance.

Mayari R *makes it lighter—stronger—longer lasting*

Greater ease in use accompanies products made lighter with . . . Dow

MAGNESIUM

the world's lightest structural metal!



If your product is designed to save manpower, one metal—Magnesium—deserves your first consideration.

Magnesium is the world's lightest structural metal. It gives portable tools new found lightness because it is a full one-third lighter than any other light metal. Saws, hand tools and countless other products become easier to lift and move—easier to sell—with magnesium. And this bonus—this premium of lightness—is yours without sacrificing needed strength and durability, because parts made from magnesium are sturdy and long lasting.

Give your product the vital selling advantage of noticeably greater ease in use—switch to magnesium. Write for a free copy of "How Magnesium Pays," a book filled with actual case studies of successful magnesium applications.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

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Cut Dead Weight
And Production Costs, Too . . .
With Magnesium Die Castings

Magnesium die castings are the obvious choice for portable equipment. They enable designers to save pounds and dollars at the same time. Magnesium die castings are as strong as they are light. And they can be cast to extremely close tolerances which eliminates much costly machining.

Lighter Products Sell—make your product Magnesium Light

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Methods of Machining Free-Cutting Brass Rod

Free-cutting brass rod is most commonly used for the manufacture of screw machine items. Bridgeport's Ledrite, containing 61% copper, 3.4% lead and the remainder zinc, has a machinability rating of 100. Other copper-base alloys are compared to free cutting brass rod for machinability rating.

Lead decreases ductility, thereby causing the chip to break up rapidly with a sharp reduction in heat-producing friction. These characteristics permit higher speeds and the use of a lighter cutting compound which produces greater cooling.

Cutting Tools

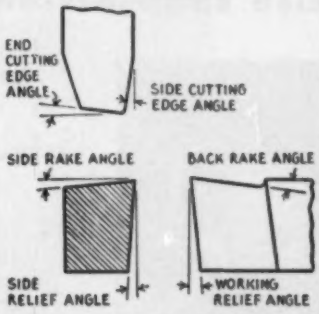
Despite the greater speeds and longer life possible with tungsten carbide tools, high-speed tools give such satisfactory service on this alloy that they are used widely in screw machine plants. Intricate forming tools are thereby produced at lower original cost. This is helpful on short runs.

Speeds and Feeds

Normal turning speeds with high-speed tools for free-cutting rod are between 300-700 surface feet per minute with a roughing feed in the neighborhood of 0.006" to 0.020". With carbide cutters, speeds up to 1000 fpm are attained with feeds of 0.005-0.025".

The low ductility of the metal permits minimum rake and clearance angles on the tool which gives greater support to the cutting edge.

TURNING TOOL NOMENCLATURE



High speeds are also possible in drilling and tapping, which means that there is no necessity for reducing speeds for these operations, with the subsequent loss in output.

Drills normally are flattened on the cutting edge to prevent hogging in by reducing the rake to zero. The rake angles on taps should also be held to a minimum.

DRILLING DATA

Clearance Angle	*Drill Point Angle*	*Cutting Edge*	*Speed Feet Per Min.*
12°-15°	118°	Flatten to 0° Rake	200-300

REAMING DATA

Back Rake	*Clearance*	*Land*	*Speed*
0°	6°-8°	5°-10°	100-200

TAPPING DATA

Rake	*Chamfer*	*Coolant*
2°-4°	10°-15° Two or Three Threads	Soluble Oil, Light Mineral Oil

TURNING DATA

	Tool Grinding				Speeds and Feeds for Turning			Coolant
70-100 Machinability	*Relief Angles Degrees Side*	*Working*	*Rake Angles Degrees Back*	*Side*	*Surface Speed Ft. per Min.*	*Roughing Feed*	*Finishing Feed*	
HS Steel Tool	0-5	6	0	0-3	300-700	0.006-0.020	0.003-0.015	Light Mineral or Soluble Oil
Carbide Tipped Tool	4-6	4-6	0	2-4	500-1000	0.015-0.025	0.005-0.015	

Coolant-Lubricant

For a coolant-lubricant either a light mineral oil or soluble oil in the ratio of 25 parts water to 1 of oil is satisfactory. At high speeds, however, it is important that the stream or streams of cutting compounds do not splash off work and tools. Normally the outlets are fish-tailed to spread the coolant and also reduce the pressure at the nozzle.

Where considerable threading or tapping is involved, low mineral oils are generally used although the soluble oil solution can be enriched by reducing the proportions of water to oil.

Cold-Working Operations

Cold swaging or other cold working operations cannot be carried out to any great degree on this highly-leaded material. For this reason Ledrite 2 has been developed. There is 63% copper, 1.8% lead and the remainder zinc in this alloy. Operations such as roll threading, knurling, forming and expanding can be carried out on this alloy yet the machinability rating is high.

Bridgeport rod has many other fine features—accurate gauge, fine surface, uniformly excellent quality. When a special problem presents itself, consult our Laboratory.

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MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
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Noranda Copper and Brass Limited, Montreal

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Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

MICRO SWITCH ENGINEERING —the plus service

MICRO SWITCH ENGINEERING Field Service

How MICRO SWITCH ENGINEERING* produced a precise snap-action switch to withstand severe aircraft vibration

Large illustration shows torque pressure switch mounted on aircraft engine just back of propeller . . . an area of severe vibration. Smaller illustration shows torque pressure switch with cover removed, showing MICRO precision switch. Drawings show how oil pressure from running engine keeps switch inoperative. Power failure permits piston to return, switch closes and propellers are feathered instantly.

A manufacturer of torque pressure switches for aircraft required a precise snap-action switch for its operating element.

The torque pressure switch was developed to feather the aircraft propellers automatically and instantly in case of engine failure. Located on the engine, just back of the propeller, it was subject to severe vibration. Standard snap-action switches were tried and found inadequate..

MICRO SWITCH Engineers were called in. From their experience with vibration problems and their detailed knowledge of precise snap-action switches, they were able to recommend construction changes and produce a special switch which exactly met the requirement..

This is but one of hundreds of instances where MICRO SWITCH ENGINEERING has cooperated with design engineers to produce just the right switch for an exacting application. This service is at YOUR beck and call.

If your design problem involves precision snap-action switches, call a MICRO SWITCH Engineer. We may have already solved the problem . . . for somebody else. If not, MICRO engineers will cooperate in the development of just the switch you need.

for precision switch users!

MICRO SWITCH ENGINEERING Product Development

MICRO SWITCH ENGINEERING Quality Standards

MICRO SWITCH ENGINEERING* has developed more than 4600 types of precise snap-action switches to meet specific applications!

This new MICRO-LIMIT Precision Switch is one of the most versatile switches ever produced to meet the needs of severe industrial use.

Roller arm actuator is adjustable to 870 positive lock positions through 360°.

Operating head may be mounted in any of four positions.

Field adjustable to operate in either or both directions.

Switch mechanism operates through a seal which completely protects switching element.

This new precise snap-action switch is but one of 4600 different types of MICRO precision switches which MICRO SWITCH ENGINEERING has made available to design engineers to meet the requirements of specific applications.

MICRO SWITCH ENGINEERING* offers you the utmost in quality standards for precision snap-action switches

1. *Every roll of beryllium copper for MICRO precision switch springs gauged for exact thickness.*
2. **All beryllium copper is metallurgically analyzed and subjected to exhaustive fatigue tests.**
3. **Photomicrographs are made of many materials. These are carefully analyzed by MICRO metallurgical engineers.**
4. **Mechanical action of all standard production switches and new designs is carefully studied by slow motion photography.**
5. **All material used in MICRO precision switches are subject to rigid quality control by statistical methods.**
6. **Highest quality control of plastic parts is maintained by their production in MICRO's own plastics department.**

MICRO... first name in precision switches

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MICRO SWITCH

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FINISHABILITY!

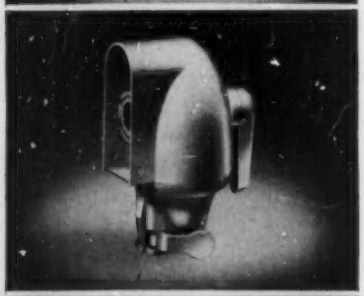
Yes, ZINC DIE CASTINGS CAN TAKE ALL OF THESE FINISHES

ELECTROPLATING

If it's a beautiful plated finish you are after, the die casting should be ZINC. The ability of ZINC die castings to take all types of electrodeposited coatings *easily* and *economically* is one of the primary reasons why ZINC gets the call over other commonly used die casting metals. The ZINC die cast bathroom hardware at the right is finished with a durable copper-nickel-chromium plate.

ORGANIC COATINGS

Because of the smooth as-cast surfaces of ZINC die castings, enamels, lacquers or paints are applied with a minimum of surface preparation. Such finishes can be air-dried or baked, depending upon service requirements. See the gleaming white enamel coating on the ZINC die cast washing machine wringer-head pictured at the right.



SPECIAL FINISHES

Special finishes for particular protective or beautifying effects are frequently applied on ZINC die castings. These take the form of chemical treatments, plastic coatings or decalcomanias. The automobile carburetor at the right has been Cronak treated—a corrosion-inhibiting chromate coating process developed and patented by The New Jersey Zinc Company.

A combination of many advantages—of which finishability is only one—make ZINC die castings the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss these advantages with you. Or write to us.

The New Jersey Zinc Company, 160 Front Street, New York 7, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

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Houghton purposely delayed reprinting because of the changes which would be necessary when packing standardization — pioneered by our engineers — was finally approved by the Joint Industry Conference.

Now the new handbook on synthetic rubber packings has been completed, including dash numbers for easy ordering of standard sizes, plus other data added since the first edition was compiled. You may have a free copy by writing us on your letterhead or filling in the coupon below.

And please bear this in mind — that the engineering knowledge necessary to compile such a handbook will be most helpful to you when you reach the point in design work of having to include an effective packing installation. So use Houghton's experience, and Houghton's packings. We make all types — will recommend the best for your particular application.

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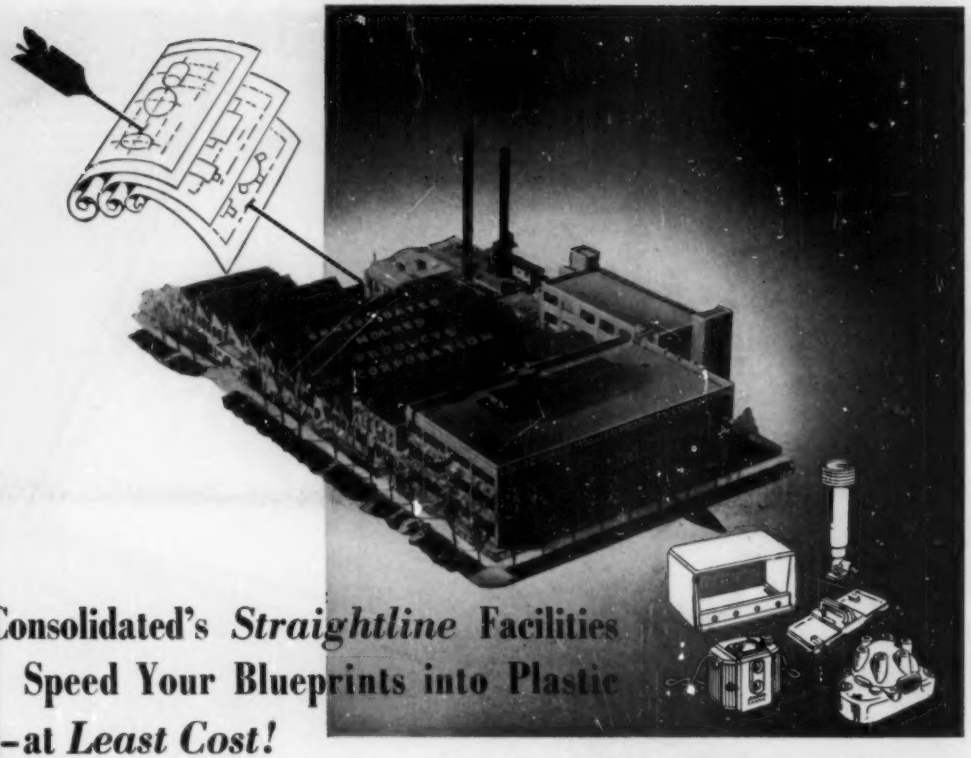

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CURRENTLY, A foremost plastic materials supplier is investing good advertising money to bring home this thought . . . *"It pays to use your custom molder's know-how!"*

This timely bit of advice, so well given, is deserving of being equally well taken.

Here, at Consolidated, we offer manufacturers a degree of production know-how that is long on experience—advantageously diversified—desirably a complete under-one-roof responsibility — thoroughly dependable — alert — cooperative!

When we are asked . . . *"How much?"*— our answering bid usually reveals *"How little!"* With on-premise facilities in excess of a million dollars, we've what it takes to save you those important pennies per piece!

That the types of service we render can custom-fit your particular plastic requirements, is indicated by the customer confidence reposed in us by America's leading manufacturers in practically every field of industry.

Call in a Consolidated sales engineer . . . and do so during the early stages of your plastic thinking. His assistance-qualifications will enable you to plan properly . . . and profitably. Your inquiry is cordially invited!

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3. Precise Mold Construction
4. Laboratory-Checked Materials
5. Selective Production Processes
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CMP

"Your Blueprint in Plastics"

WE CAN SHOW YOU THESE

...but we can't show you

SIRVENE

That's because Sirvene means something different in every application. Primarily it is a specially compounded elastomer designed to meet a critical operational requirement. No two uses of Sirvene are alike. Every purpose, every design and every formula is individual. You, the design engineer, determine the need and type, and Sirvene engineers work with you in developing the particular part required for the efficient operation of your mechanism. The physical properties and resistance qualities are custom developed to do just *your* job.

At the same time, the name Sirvene automatically implies one of the longest experiences in elastomer development in this country. Chicago Rawhide was one of the first to pioneer in combining elastomers for the purpose of producing specified qualities and characteristics. Today, many outstanding leaders in all branches of industry depend upon Sirvene for the solution to previously "impossible" mechanical sealing and protection problems. Sirvene can also mean success in your search for an unknown pliable part.

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1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables

OTHER C/R PRODUCTS
PERFECT Oil Seals
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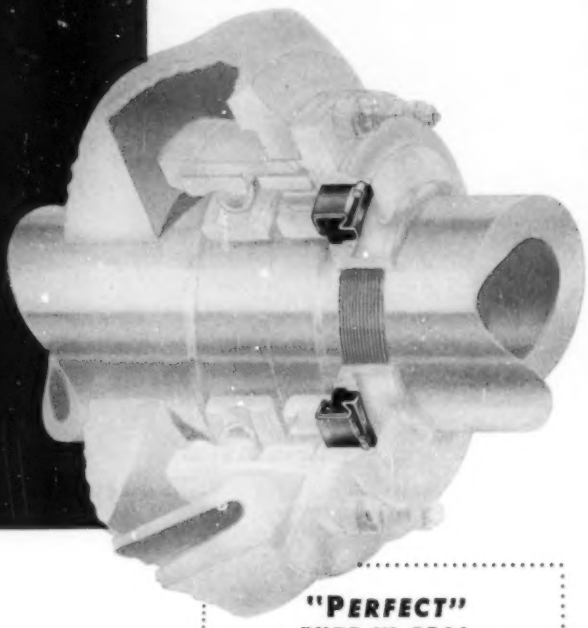
SIRVENE

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

HEADACHES ELIMINATED



by C/R engineering

"PERFECT" TYPE W SEAL...

One of the many seals specially engineered by Chicago Rawhide to solve unusual fluid sealing problems.

The development of a complicated machine was in the trial stages. Stock oil seals had been installed at eight points. Each one failed. *Dependable* sealing had not been achieved.

Chicago Rawhide engineers were called in. They found that each sealing point represented a problem which required *individual* engineering. Eight "Perfect" Oil Seals were developed. In each, profile, lip pressure, packing member and retainer were all correctly designed and integrated to do *one* particular sealing job. Eight headaches were eliminated.

Such experiences are common at Chicago Rawhide. For twenty years, "Perfect" Oil Seals have been specially engineered to solve fluid retention and exclusion problems in every type of machinery and equipment. They have helped to maintain the highest standards of quality and performance. And, they will do the same for you.

Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.

CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue **OIL SEAL DIVISION** Chicago 22, Illinois

Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of *Sirvene* synthetic rubber and *Sirvis* mechanical leather.

ENGINEERS: We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

PERFECT *Oil Seals*

These 2 TIMKEN® wear-resistant steels shipped in 24 hours!

YOU CAN GET DELIVERY NOW FROM WAREHOUSE STOCK!

TIMKEN® 52100 and Timken "Nickel-moly"—general purpose steels with good hardenability and wear resistance—will do 90% of your hollow parts jobs. And they're available in small quantities for immediate delivery within 24 hours of receipt of your order!

Timken 52100 is ideal for such machined parts as diesel injection pump parts, lathe centers, slitting knives and many other applications. It can be heat treated to file hardness and tempered back to any desired point. In moderate sections it is through-hardening. 52100 is available in 101 sizes, from 1" to 10½" O. D.

Timken "Nickel-moly" provides exceptional stamina and shock absorbent qualities. It is a low carbon, carburizing steel that develops high case hardness and tough inner core. 52 sizes range from 1.389" to 10.223" O. D.

You're assured of uniformity from tube to tube and shipment to shipment by careful quality control from melting through final tube inspection. For stock lists, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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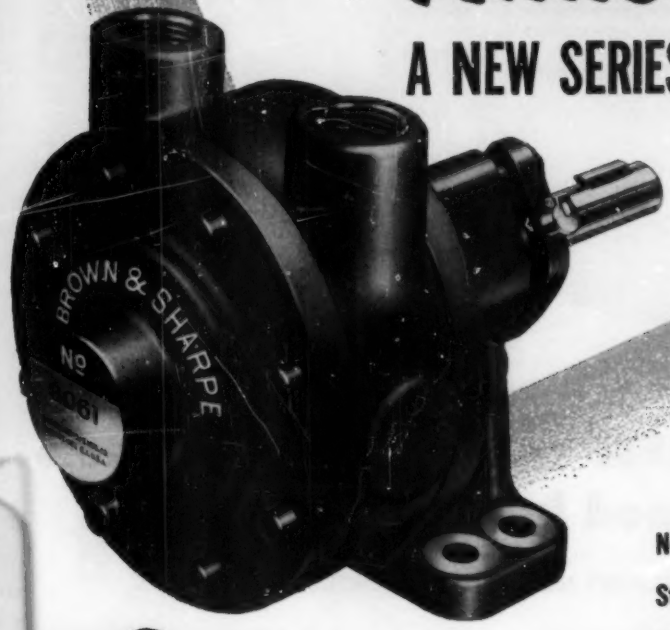
Announcing

A NEW SERIES OF

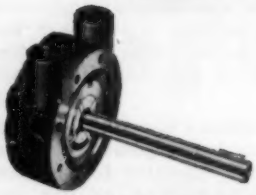
AUTOMATIC REVERSING VANE PUMPS



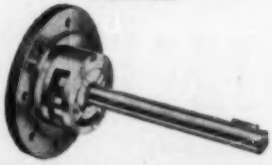
Nos. 8021, 8061, 8101 — and

Stripped Models with Housings

Stripped Models without Housings



Stripped Models with Housings, Nos. 8022, 8062 and 8102. Simplify installation, particularly where internal discharge and suction ports are not readily incorporated in the machine design, or where outside piping is desirable.



Stripped Models without Housings, Nos. 8023, 8063 and 8103. Made for manufacturers who wish to utilize pumps as integral parts of machines with suction and discharge ports incorporated in the machine castings. Provides compact installation ... minimum projection from machine surfaces.

Many important and convenient features have been designed into this New Series of Brown & Sharpe Pumps for lubrication and coolant systems on machines that reverse. Heading the list is the fully-automatic reversing feature with unidirectional flow. Other features include ... three sizes—2½, 5 and 11½ gpm at 0 pressure, max. speed 1140 R.P.M. ... easy changeability of flow direction from one port to the other, in the field ... mounting design that permits foot to be set in 4 different positions with ports held vertical.

For integral mounting, each size pump is furnished also as a stripped model *with* housing, or stripped model *without* housing. Easily installed with minimum number of machining operations. Complete information available in new Bulletin. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

We urge buying through the Distributor

BROWN & SHARPE PUMPS B·S

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MEMO

TO: Industry's Production Executives

FROM: Geuder, Paeschke and Frey Co.

It's possible for you to end many production headaches by using the overall metal processing facilities offered by G. P. & F.'s Complete Fabricating and Finishing Service. This includes:

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Add to your manufacturing profits by obtaining from a single source completed units—made to your specifications —finished—ready to assemble—or completely assembled.

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—and speed up your machine sales

Increased output, even as much as 25%, so frequently obtained with REEVES Speed Control, is not all that new machine buyers are looking for. Higher quality of production, fewer rejects, and less waste of labor and materials, make a similar contribution to lower production costs.

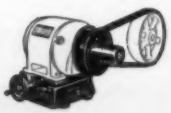
All of which calls for more than mere speed adjustability. It calls for *accurate, positive, non-fluctuating power transmission,* at the best speed for every job. It calls for infinitely variable speed regulation that will not budge from its setting, regardless of speed or load—the variable speed control that is attained with the non-slipping, wedge-like action of the rugged REEVES endless cord V-belt, that provides dependably *controlled tension* at all driving speeds.

When machine speeds can be adjusted, instantly and positively, without stopping the machine, as with REEVES Speed Control, the operator can fit the speed to the job, to any change in operating conditions, to the kind, quality or condition of material, to his own skill and efficiency. Thus, highest possible quality and quantity of production are maintained, with minimum waste of time and material. *The machine sells easier because it does more work, better work, at lower cost.*

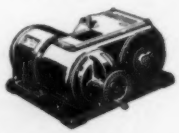
Why not investigate the advantages of REEVES Speed Control, for your machines today? The wide range of sizes of three (not one) basic units in the complete REEVES line simplifies the installation, insures the correct unit for the job, and keeps the cost for standard equipment at the lowest possible figure. There's a REEVES representative, a member of our nation-wide staff of speed control engineers, in your city or vicinity. He will be glad to discuss all of these details with you, at your convenience, and entirely without obligation on your part. Send for new catalog No. K26-3N, just off the press.

The Three Basic Reeves Units

VARIABLE SPEED TRANSMISSION for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Sizes—fractional to 87 hp.



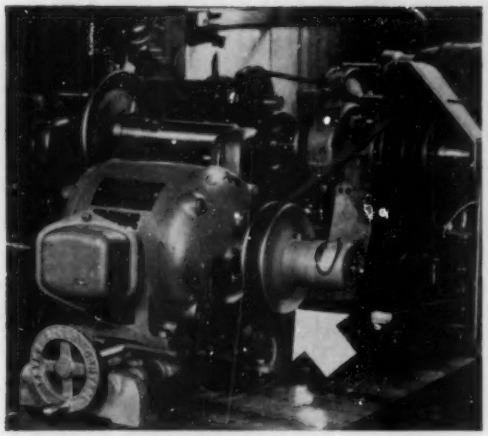
VARI-SPEED MOTOR PULLEY provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. Sizes to 10 hp.



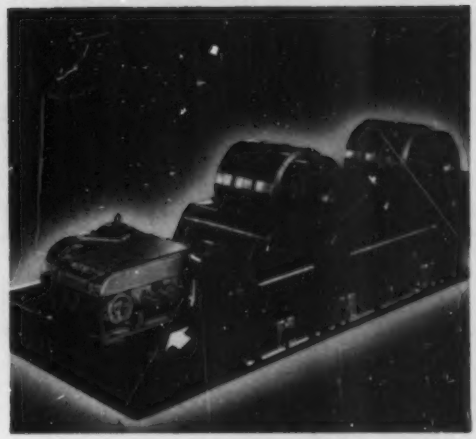
MOTODRIVE combines motor, speed varying mechanism and reduction gears in single unit. Speed variations 2:1 to 6:1 inclusive. Sizes to 20 hp.

And Now a "Junior" REEVES for Lightest Machines

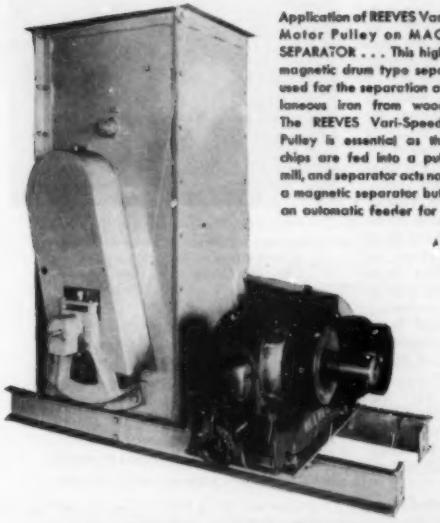
The latest member of the REEVES "family" of variable speed control units. Simplified, low cost unit is ideal for light duty lathes, saws, grinders, drill presses, pumps, etc. Forms actual driving element between motor and driven machine. Provides the right speed for every operation. Covers the entire speed range smoothly, without jumps or steps, without stopping the machine. Easy to apply—easy to use—uses any standard constant speed motor, any standard V-belt. Ask for Bulletin V-4912.



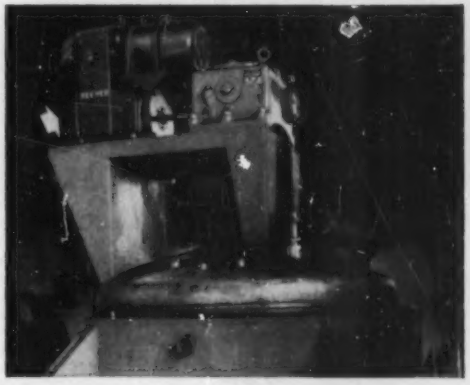
Application of new Vari-Speed Jr. unit on a dynamic balancing machine. In this particular instance the Vari-Speed unit replaced a step-cone pulley so that by simply turning the handwheel, without stopping the machine, the driving speed can be quickly changed to compensate for different sizes and weights of pieces tested. Also, through the use of this variable speed drive, the operator can check the pieces being tested under all speeds that the piece might encounter in actual operation.



Application of REEVES Variable Speed Transmission on a Heavy Duty Turning Roll. These machines are used for rotating extremely large and heavy vessels, for manual or automatic welding. Size of vessel determines rotating speed, accurately controlled with the REEVES Transmission. Unit shown is a No. O-B REEVES giving an 8:1 speed variation and operating speed ranging from 5" to 40" per minute.



Application of REEVES Vari-Speed Motor Pulley on MAGNETIC SEPARATOR . . . This high power magnetic drum type separator is used for the separation of miscellaneous iron from wood chips. The REEVES Vari-Speed Motor Pulley is essential as the wood chips are fed into a pulverizing mill, and separator acts not only as a magnetic separator but also as an automatic feeder for the mill.



REEVES Motodrive with 5 H.P. explosion proof motor connected directly to a worm gear reducer to drive agitator at a speed between 26 and 130 rpm. This unit is a 500-gallon jacketed stainless steel kettle for use in preparation of penicillin.

REEVES PULLEY COMPANY • COLUMBUS, INDIANA

ACCURATE • VARIABLE

Reeves Speed Control

GIVES THE RIGHT SPEED FOR EVERY JOB!

Recognized Leader in the Specialized Field of Speed Control Engineering

MR. PRODUCT DESIGNER

Your company probably doesn't make plant caps, but isn't there an idea in this success story applicable to your business?

Get in touch with Monsanto today.

We'll gladly work with you.

"This product would have been impossible...if we hadn't scrapped **habit-itis** first"

SAYS

E. V. Alvarez

General Manager,
Plas-Tex Corporation
Los Angeles, California

"For years, growers have been protecting tender seedlings with plant caps made of oil-paper," explains Mr. Alvarez. "Today, because we discarded 'habit-thinking,' our customers are cutting labor costs of installation a full 20%, and are getting greater yields, earlier crops, with new plant caps made of Lustrex."

When Plas-Tex went to work to scrap "habit-itis," they learned by actual test that plant caps made of Lustrex styrene can be installed by one man at the rate of 500 in a half-hour—15 times faster than paper caps. They found that Lustrex styrene plant caps will last for years, compared to the half-a-season life of their predecessors. More important, in comparative tests, the plant caps made of transparent Lustrex, admitting the sun's rays and providing more moisture retention and frost protection for young seeds, produced an unprecedented 100 per cent yield.

Like Plas-Tex, other manufacturers, too, are discarding "habit-itis" for real creative thinking in the development of new products and new ways to improve old ones. In many cases, plastics will play a part in that improvement.

Investigate the possibilities of plastics in your business. Write Monsanto today. Our technicians will gladly work with you and will put you in touch with a molder or fabricator best qualified to serve you.

"Hotouse" plant caps of Lustrex styrene for home gardens and commercial growers. Developed and sold by Plas-Tex Corporation, Los Angeles.

Use the handy coupon for information about Monsanto Plastics, the largest family of plastics in the world. Lustrex: Reg. U. S. Pat. Off.

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Please send me "What Monsanto Plastics can do for you."

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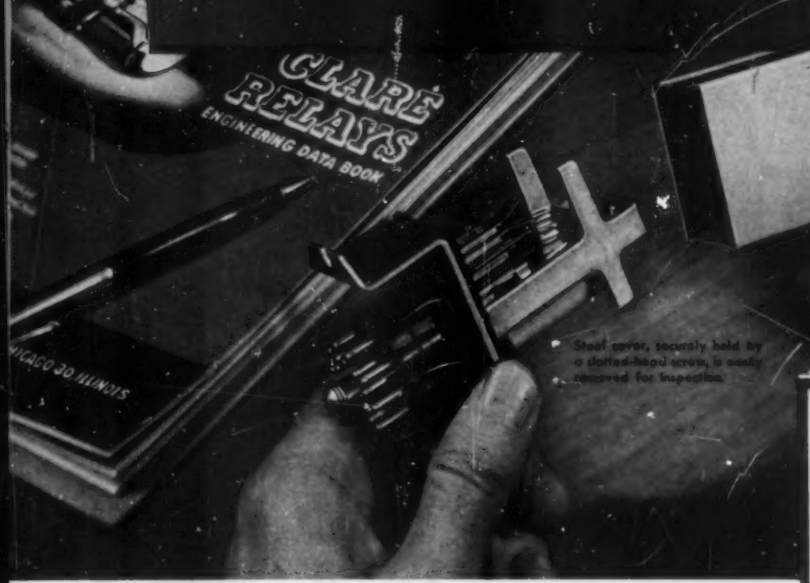
CLARE TYPE "J" TWIN CONTACT RELAY



Steel cover, securely held by a slotted-head screw, is easily removed for inspection.

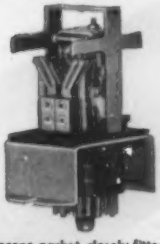
● This new CLARE dust-tight plug-in enclosure for the small Type "J" Relay offers designers a number of unusual features for installation on industrial equipment.

Entrance of dust is prevented by the steel cover and by use of a Neoprene gasket which is closely fitted at the factory to the relay terminals. The dust-tight cover is easily removed for inspection. Use of standard radio plug simplifies installation and cuts wiring costs. Base is secured to chassis to prevent plug from being jarred or accidentally pulled from its socket.

Exclusive design of the CLARE Type "J" Relay allows the twin contacts to operate independently of each other. One contact is sure to close, reducing contact failure to the practical limit. This relay combines all the best features of the conventional telephone-type relay with small size and light weight. It provides unusually high current-carrying capacity, large contact spring capacity, extreme sensitivity and high operating speed.

This new dust-tight enclosed relay is one of many outstanding CLARE contributions in the development of new and better relay components for industry. CLARE Sales Engineers are located in principal cities to consult with you on your relay problems. Call them direct or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable Address: CLARELAY. In Canada: Canadian Line Materials Ltd., Toronto 13.

Write for Bulletin No. 108

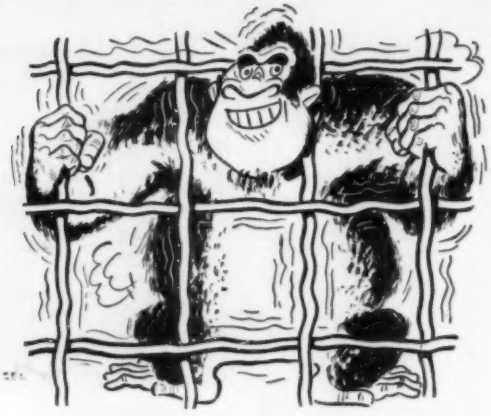


Neoprene gasket, closely fitted at factory to relay terminals, between base and cover, effectively occludes dust.

Plug is standard radio-type plug. Standard finishes are silver lustre lacquer for cover, cadmium for base. Retaining screws hold base securely to panel.

CLARE RELAYS

Why Bundyweld is



IT'S EXTRA-STRONG...CAN TAKE A SHAKING, A MAJOR POINT IN AUTO BRAKING.

So strong it's in the hydraulic brake line systems of 95% of today's cars, trucks and tractors. Whatever you make, from a tank to a trinket—if resistance to vibration fatigue is a must, just call for Bundyweld.

Do you use tubing?

Are you even thinking of using tubing? Check on Bundyweld *first.*

Here's the miracle tubing of industry that, time after time, has helped make a good product even better, or helped turn an idea into a successful product.

No other tubing offers all Bundyweld's advantages and superior features . . . as you can see at a glance.

WE ROLL IT LATERALLY, TWICE AROUND, BY A PATENTED PROCESS, WORLD RENOWNED.

Bundyweld is the only tubing that's double-walled from a single strip. Leakproof, extra-rugged and sturdy, yet thinner walled, Bundyweld is already serving thousands of profitable design, functional and structural applications in American industry.

First, a single strip of basic metal, coated with a bonding metal, is . . .

rolled twice around into a tube of uniform thickness, then . . .

passed through a furnace. Bonding metal fuses with basic metal, presto—

Bundyweld . . . double-walled and brazed through 360° of wall contact.

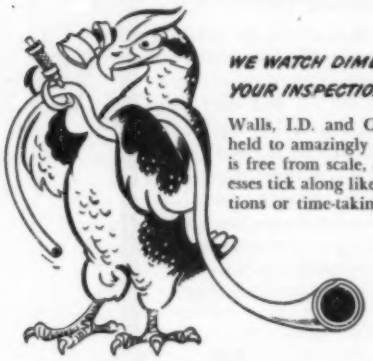
the quality tubing

IT'S EASY TO FORM AND FABRICATE, IT'S THINNER WALLED AND LIGHT IN WEIGHT.

Double-walled Bundyweld Tubing is a cinch to bend and it takes more bending . . . perfect (with its strength) for tubular furniture and toys, gas range and refrigerant lines, beer coils and radiant heating systems, to name only a few of Bundyweld's present outstanding applications.

IT WON'T COLLAPSE WITH KNOCKS AND BENDS, ANOTHER TUBING HEADACHE ENDS!

We've seen hundreds and hundreds of instances where a simple application of Bundyweld has lowered costs, improved design or speeded production . . . to some manufacturer's profit. Why not in a product of *yours* to give you a plus in rugged, dependable performance all down the line?



WE WATCH DIMENSIONS LIKE A HAWK, YOUR INSPECTION CREW WILL NEVER SQUAWK.

Walls, I.D. and O.D. of Bundyweld are rigidly held to amazingly close tolerances. Finished tube is free from scale, as well. Your fabrication processes tick along like a watch, without costly inspections or time-taking rejects.

Bundyweld
It comes in steel, Monel or nickel,
The cost is really low.
If you've a tubing problem,
Write Bundy—see below.

FREE! New 20-page booklet, crammed with why's and wherefore's on Bundyweld's dependability, together with a list of successful Bundyweld applications that may spark an idea for you. For booklet, or queries on any possible use of tubing, call or write: ***Bundy Tubing Company, Detroit 14, Mich.***

Bundyweld® Tubing

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Bundy Tubing Distributors and Representatives: Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • **Chattanooga 2, Tenn.:** Peirson-Deshler Co., 823-824 Chattanooga Bank Bldg. • **Chicago 32, Ill.:** Lapham-Hickey Co., 3333 W. 47th Place • **Elizabeth, New Jersey:** A. B. Murray Co., Inc., Post Office Box 476 • **Philadelphia 3, Penn.:** Rutan & Co., 404 Architects Bldg. • **San Francisco 10, Calif.:** Pacific Metals Co., Ltd., 3100 19th St. • **Seattle 4, Wash.:** Eagle Metals Co., 3628 E. Marginal Way **Toronto 5, Ontario, Canada:** Alloy Metal Sales, Ltd., 681 Bay St. • **Bundyweld Nickel and Monel Tubing is sold by distributors of Nickel and Nickel alloys in principal cities.**

WE NEVER START ANYTHING WE CAN'T FINISH *RIGHT*

It has always been Moraine's policy to turn down orders for metal powder parts unless we are positively sure that the powder metallurgy process will work to the advantage of the purchaser. That policy is paying off, too. It brings us inquiries from prospective customers who know that, if we *do* undertake their work, they will benefit through savings in costs or through improved performance.

If you are using parts that might be made better and more economically by powder metallurgy, consult our engineers. If the shape of a part permits good die fill and correct density . . . if its required physical properties and tolerances can be obtained by normal production methods . . . and if it is to be made in quantities sufficient to justify tooling costs . . . then, and only then, will we take on the job. And, even before we begin to produce, you can be assured of dependable results—for we never start anything we can't finish *right.*

MORAINE PRODUCTS

DIVISION OF **GENERAL MOTORS** DAYTON, OHIO

METAL POWDER PARTS BY MORAINE

NATIONAL OIL SEAL LOGBOOK

DIRT EXCLUDERS FOR HYDRAULIC & PNEUMATIC ACTUATED DEVICES

Truck hoists and hydraulic lifts of all kinds usually must perform under extreme operating and surrounding conditions. Piston shafts sometimes become caked with heavy abrasives; fine dust, muck and dirt are common. Shafts are many times subject to angular thrusts which cause considerable movement off center (Fig. 1). These conditions can result in the entry of copious quantities of extraneous matter into the cylinder causing excessive wear or failure of pressure seals whether of "O" ring or packing gland type.

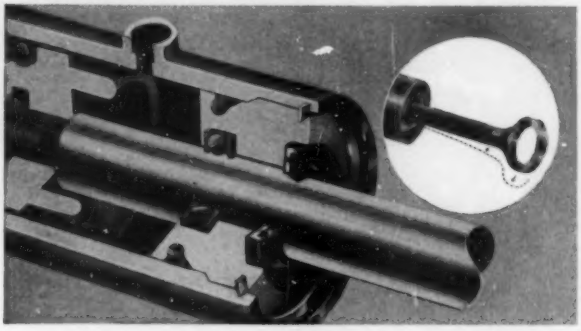

Fig. 1. Typical section of hydraulic actuated mechanism showing use of National Seal as dust excluder—note "O" rings and back-up rings.

Rugged, yet flexible, Syntech* oil seals of the type illustrated (Fig. 2) provide excellent protection for such equipment. These seals act as a wiper on the reciprocating shaft to clear away extraneous abrasive matter. Where ice or heavy caking of dirt is encountered a combination of bronze ring scraper and a Syntech* seal (Fig. 3) can be employed—the bronze scraper to break up and remove the heavy cake and the oil seal to clean the shaft.

These National Syntech* Seals have been extremely successful in applications of this kind where leather type seals and other devices have failed. The Syntech* rubber is flexible enough to follow the shaft eccentricities, yet sturdy enough to keep from buckling under as the shaft moves back and forth, even under extreme shaft eccentricities.

National Syntech* Seals in combination with "O" rings provide a close approach to the ideal for hydraulic or pneumatic actuators of all types and sizes. However, leather or other sealing member materials are supplied in a few special applications. National can also supply "O" rings and back up rings as shown (Fig. 1) to meet the most rigid specifications in a complete range of sizes. Your inquiry will receive prompt attention.

Fig. 2. National 340,000 Series springless type seal. A good design for use in hydraulic or pneumatic actuators.

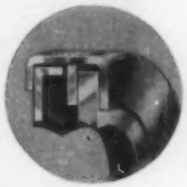

Fig. 3. Combination National Syntech* Seal with bronze scraper ring.

Trade Mark Registered

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, Calif.
Plants: Redwood City and Los Angeles, Calif.; Van Wert, Ohio

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Square D MOTOR STARTERS

Square D's **design leadership** is reflected in important features, many of which were developed specifically to meet the requirements of the machine tool industry.

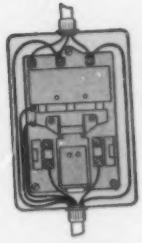
Generous wiring space . . . simple contact change . . . quick coil removal . . . additional electrical interlocks . . . long life . . . NEMA standardization . . . simplified maintenance. These are features which put Square D on the preferred list of many of the country's outstanding machine tool builders.

SQUARE D COMPANY

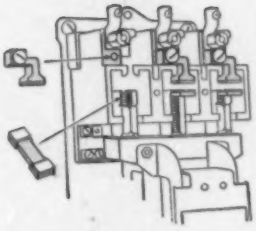
DETROIT · MILWAUKEE · LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S. A., MEXICO CITY, D. F.

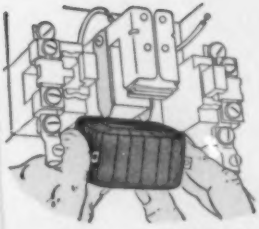
—an example of DESIGN LEADERSHIP



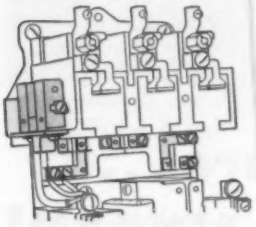
1) EASY TO WIRE—Compact starter design provides generous wiring space with minimum box size. Either pressure wire connectors or solderless lugs permit leads to be attached quickly and securely.



2) SIMPLE CONTACT CHANGE—Removal of arc chamber cover exposes all contact surfaces. Two-piece stationary contact allows replacement without disturbing wiring.

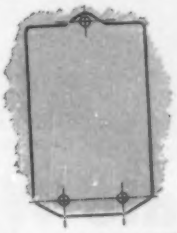


3) QUICK COIL REMOVAL—Coil readily accessible by removing arc chamber cover and lifting off armature assembly. Screwdriver only tool required.

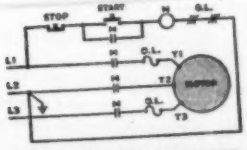


4) ADDITIONAL ELECTRICAL INTERLOCKS—Wide variety of available combinations adds flexibility to starter use in special applications.

5) LONG LIFE—Straight line, guided motion of armature and movable contact assembly eliminates bearing, simplifies construction, reduces wear.



6) NEMA STANDARDIZED MOUNTING—Base plates of Size 0, 1 and 2 starters have NEMA standard mounting holes but are also interchangeable with previous designs.



7) NEMA STANDARDIZED WIRING provides added safety, permits standardized diagrams and simplifies interchangeability of equipment.

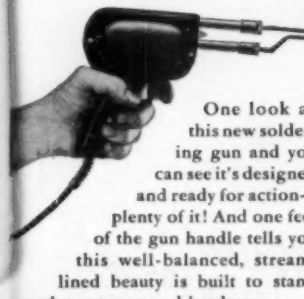
8) PACKAGED PARTS—clearly identified, simplify normal maintenance and minimize replacement part ordering and stocking problems.

Write **for BULLETIN #8536**

SQUARE D COMPANY
4041 N. Richards Street
Milwaukee 12
Wisconsin

Gun and handle made by Weller Manufacturing Co., Easton, Pa. ** Made by Chemicals Division, General Electric Company, Pittsfield, Mass.*

Handle WITHOUT Care... it's made with HYCAR!



One look at this new soldering gun and you can see it's designed and ready for action—plenty of it! And one feel of the gun handle tells you this well-balanced, streamlined beauty is built to stand rough treatment and hard use.

For the handle is molded from a newly-developed G-E Hycar-phenolic compound* that has unique advantages.

This new Hycar-phenolic compound gives molded parts a toughness and shock resistance far superior to that obtained with general purpose wood flour-filled phenolics. And Hycar imparts a resilience that enables molded parts to withstand abuse in assembly, shipping and handling.

In processing, too, it provides better molding characteristics . . . easier flow in the mold than straight phenolics . . . resistance to cracking around metal inserts in the part.

Hycar
Reg. U.S. Pat. Off.
American Rubber

What Hycar American rubber does for this new compound may start an idea percolating for you. For Hycar is highly versatile. It is used as a base material . . . as a modifier for phenolic resins . . . as a plasticizer for polyvinyl resins . . . as an adhesive base . . . as a latex for coating or impregnating. For further information, helpful technical advice, write Dept. HL-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

B. F. Goodrich Chemical Company A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

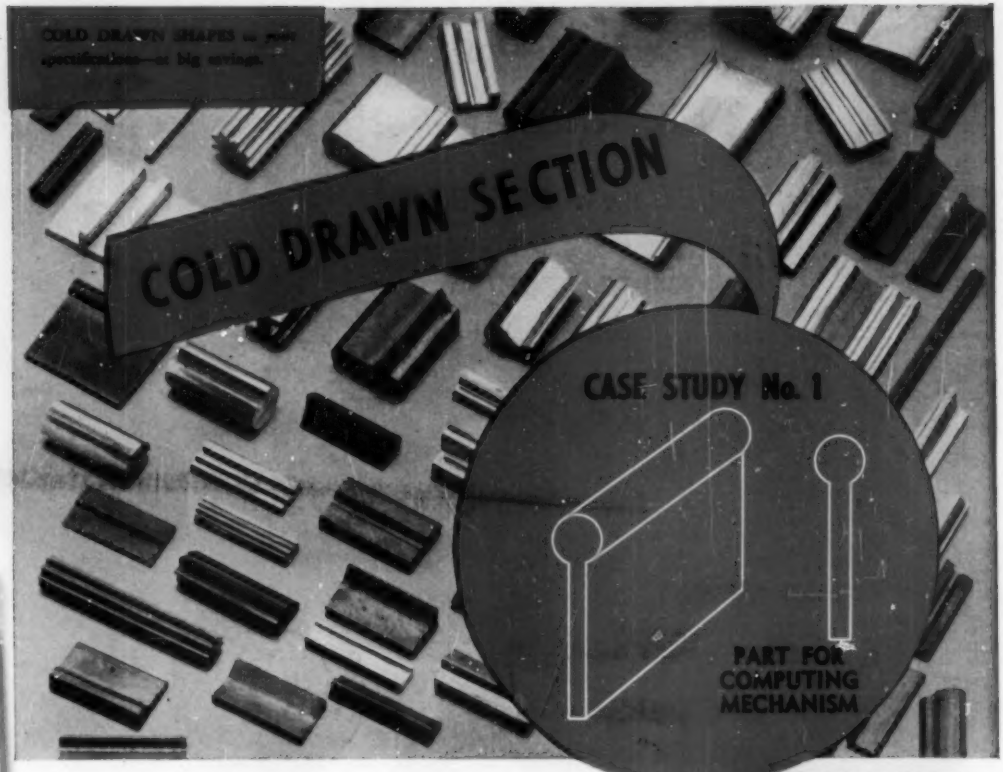
GRAMIX self-aligning bearings and **U.S.G.** carbon brushes

help make new SPEEDRILL a "fistful of p

The six GRAMIX self-aligning bearings sealed into the rugged little Speed-Way power-drill have a lot to do with its amazing long life and performance. And the pair of U.S.G. carbon brushes in this speedy tool assures absolute balance of brush pressure on the commutator at 1000 R.P.M.

GRAMIX bearings and specialty parts are die-pressed from powdered metal, *finished to size without machining.* They are sufficiently porous to retain lubricant and thus eliminate the need of regular lubrication. U.S.G. carbon brushes are available for any type motor from 1/100th to 100 H.P. Write for your copy of the new GRAMIX and the new U.S.G. Brush catalogs.

THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN
DIVISION OF THE WICKES CORPORATION

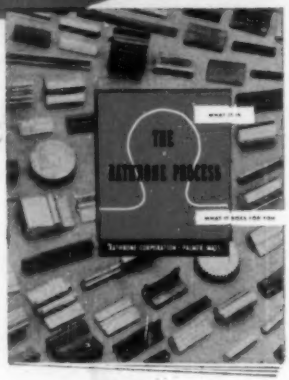


1 SHAPE REPLACES 2 PARTS . . . FOR A BIG SAVING

Costly milling and brazing operations were eliminated by the use of a RATHBONE PRECISION Cold Drawn Shape for this computing mechanism part. Formerly made up of *two* parts, costs not only were greatly reduced but a much improved part obtained.

This is a typical example of what can be accomplished by designing for cold drawn sections and then placing responsibility for producing them to your specifications with RATHBONE. Results are invariably the same: stronger, long wearing, uniformly accurate part is assured at *lower cost*. Other advantages achieved are simplification of design, easier assembly and reduced inspection costs.

Ask RATHBONE to cooperate with you. Send prints or drawings of your parts and ask for our recommendations for producing them by the RATHBONE COLD DRAWN PROCESS. No obligation of course. As pioneers in cold drawing, Rathbone can be of invaluable assistance.



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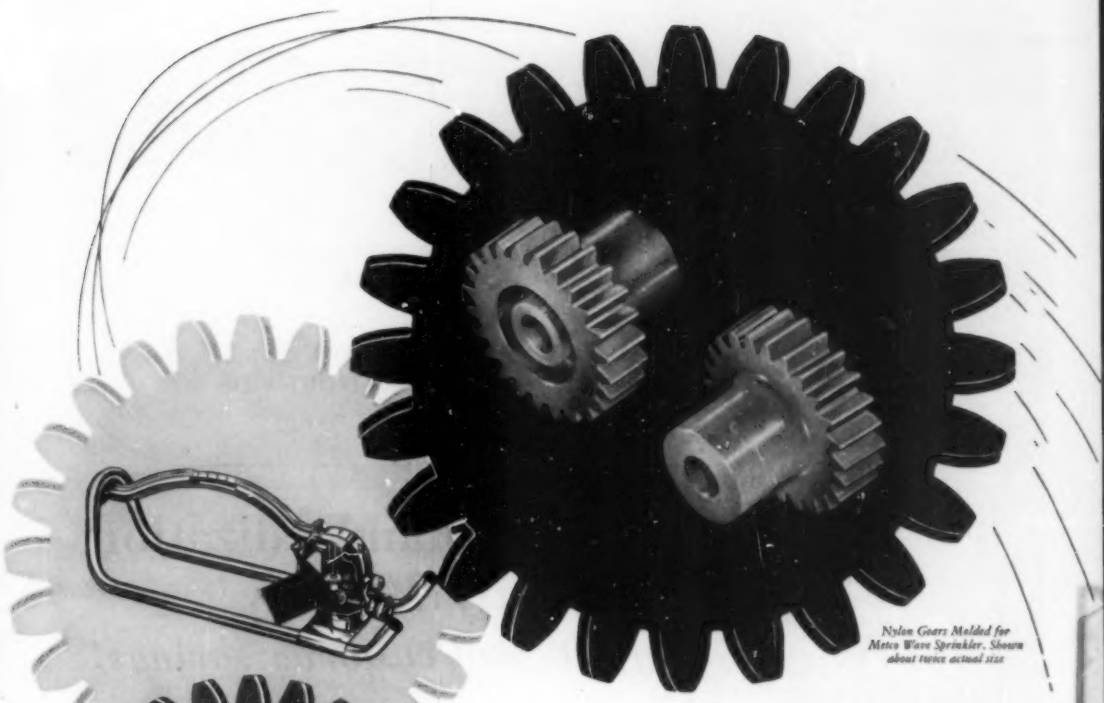

Nylon Gears Molded for Metco Wave Sprinkler. Shown about twice actual size

Skillful Molding

DOES A WELL GEARED JOB

". . . For long life with low wear, a non-metallic gear was a design requirement for the Metco Wave Sprinkler. We chose molded gears for economy and because of the wide range of materials which can be molded. We chose nylon as the molding material because of its high wet strength, low moisture absorption and abrasion resistance when operated with water as the only lubricant."

This excerpt from a letter by Mr. C. K. Wilson, Design Engineer for Metallizing Engineering Company, Long Island City, New York, effectively presents a strong case for molded gears.

If Mr. Wilson had continued in that vein, he might also have said, "We chose Elmer E. Mills Corporation because it is one of the few molders in the country equipped to mold nylon gears."

Why? Because this type of thermoplastic molding presents a challenge few molders care to meet. Since these were undercut "helical" gears instead of the straight "spur" gears, their production presented an unusually difficult job of molding and tool making. Despite the fact that only a few molders can make them, the use of thermoplastic gears is very much on the increase.

Wherever they are used, it is either a case of greater production economy, functional superiority, or both.

So when you are studying the problem of gears for your products, consider the advantages of nylon or other thermoplastic gears. Then let us show how well geared we are to solve this problem for you.

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about CHAD-PLASTICS* *piping, tubing and fittings, write for circulars containing data and illustrations.*

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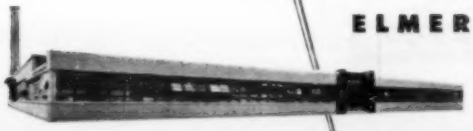

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INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Fibestos, Lucite, Nylon, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plaxone, Polyethylene, Carex, Particel, CHAD-PLASTICS*, Saran, and other Thermoplastic Materials.

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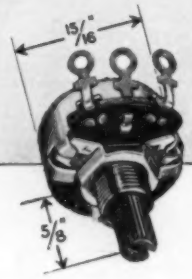
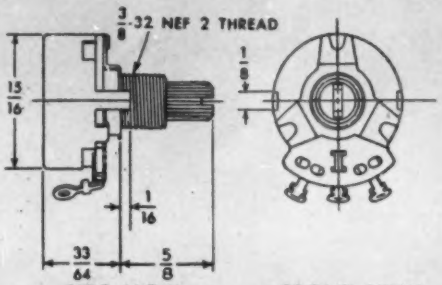
Service Beyond The Sale!





15/16" MALLORY MIDGETROL

Electrical characteristics specially designed for critical applications in television, radio and other circuits. Insulated shafts are knurled for ease in adjustment. Shaft and current-carrying parts provide 1500 volt insulation . . . 15/16" diameter saves space . . . phenolic material eliminates mechanical noise. Precision-controlled carbon element provides smooth tapers, quiet operation, accurate resistance values, less drift in television applications.

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effects real customer savings!

Mallory goes beyond the basic research and development work which results in totally new products . . . and utilizes every opportunity to pass on to customers the savings effected by product standardization.

Such is the case with the well known Mallory Midgetrol. Standardizing its diameter and shaft design resulted in cost reductions for radio and television manufacturers. The standard molded phenolic shaft provides a combination hand knurl and screwdriver slot adjustment at no extra cost . . . and it is available with either ¼" or ⅜" bushing length. In addition, the Mallory Midgetrol occupies less space than larger controls, with no sacrifice in wattage rating.

That's service beyond the sale!

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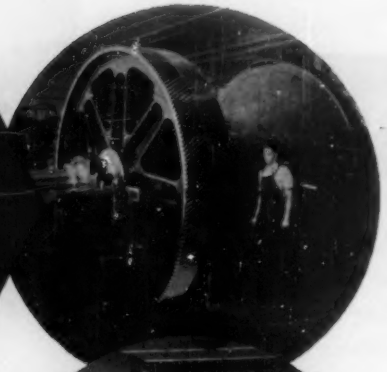
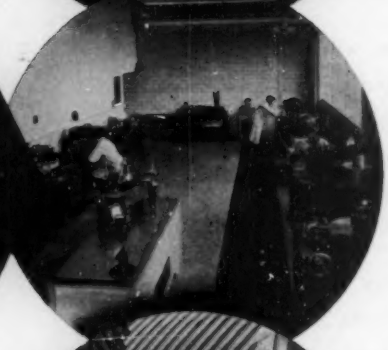


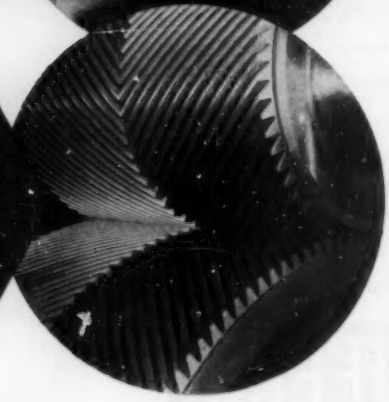
The famous *Gear with a Backbone* is made in the Buffalo plant of Farrel-Birmingham—a plant devoted to the design and manufacture of gears, gear units and gear generating machines. Here, seven of the largest gear generating machines in the world, plus numerous smaller ones, are used to cut continuous-tooth herringbone gears from "watch-fob" size up to twenty feet in diameter.

+ RESEARCH



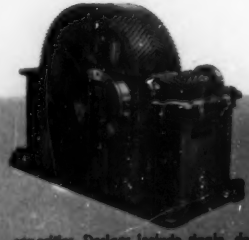
Advanced experimentation and exhaustive tests of gears are carried on in one of the most modern and fully equipped laboratories of its kind in the country.

= THE GEAR WITH A BACKBONE®



Because these gears have a *backbone*, instead of a useless center groove, the entire face width is put to work transmitting power. This provides extra strength and higher load-carrying capacity in smaller space—a definite advantage for many applications. Accuracy of tooth contour and tooth spacing, so vital to smooth, quiet operation, is inherent in the Farrel-Sykes method by which the teeth are generated.

FB-564



FARREL® SPEED REDUCERS

Farrel speed reducers are available in a wide range of ratios and capacities. Designs include single, double and multiple reduction units; speed-change units; right-angle drives and drives to meet special requirements. The Gear with a Backbone, antifriction roller bearings, and heavy cases that prevent deflection and vibration are some of the features that insure maximum efficiency and smooth, quiet operation.

When you have a gear problem, think of Farrel-Birmingham. Information and engineering assistance are available at any time, without obligation.

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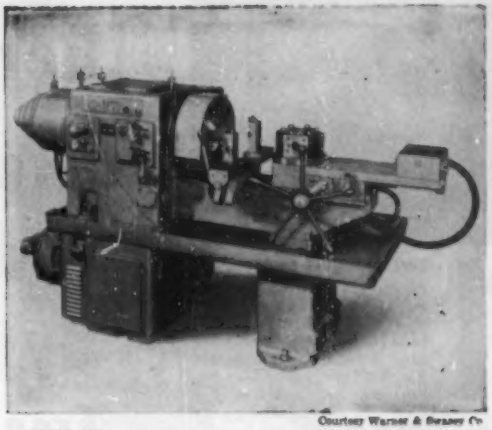
What happens—

When You Give A Turret Lathe A

BRAKE?

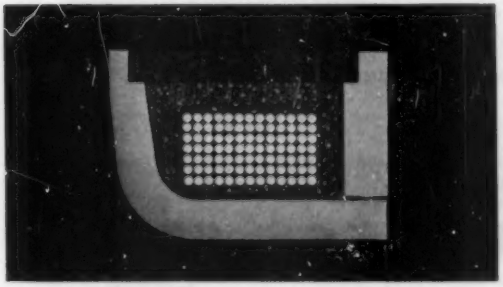


Courtesy Warner & Swasey Co.

ANSWER: You reduce machine handling time and increase production because you get fast, more fully automatic cycle operation. The W & S 16″ Electro-Cycle turret lathe, especially designed for machining non-ferrous metals, uses the Warner Electric Industrial Brake. It gives lightning fast spindle stops and closer spindle positioning — that means fast load and unload of workpieces.

THE BRAKE: Note compact design . . . readily adapts to machine or motor. Unit consists of only two parts . . . one fixed and one moving. Brake is automatically self-adjusting for life. Wide range of sizes to meet various requirements. Fits N.E.M.A. standard motor shafts.

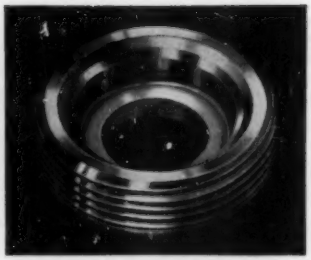
ARMATURE SECTION: Armature is only moving part. Consists of magnetic material segments welded to steel back plate . . . for unmatched heat dissipation. Heat has no effect on efficiency . . . segment expansion is linear . . . keeps full magnet contact at all times.



MAGNET SECTION: Unique electro-magnet faced with extra long-wearing, molded friction material. Power is applied through coils imbedded below. Energizing applies friction *plus* magnetic attraction for super-powerful braking or clutch action.

• Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

*ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.



here is PROOF that you can reduce unit costs by using *Carpenter* Free-Machining Stainless

1 **UNIT COST GOES DOWN!**

At first this bearing race job was classed as "impossible"—slow production, excessive rejects and a high unit cost. But now that Carpenter Stainless No. 8 (Type 303) is on the job, *each unit costs only five cents, tool life has doubled and rejects have dropped by 40%.*

2 **SAVED: $456.00 EACH YEAR ON TOOL REGRINDING!**

The cost of each Stainless part is bound to come down when you make a saving like that. *Tool life jumped from a few hours to over 15 days, plus the fact that less down time on machines gave the company production time for over 23,000 extra valve needles per year.* Small wonder that the company is pleased with Carpenter Stainless No. 8 (Type 303).

To get results like these time after time, the Stainless that feeds into your machines has to be *uniform* from bar to bar. It has to work the same in your machines month after month. And that is just why you need Carpenter Free-Machining Stainless on your jobs.

If you want positive proof that you can reduce your unit costs with *consistently uniform* Carpenter Free-Machining Stainless bar stock—do this. Place your next production order with the nearest Carpenter warehouse listed below. Send your order to Carpenter and find out for yourself that—

YOU CAN TURN IT OUT AT LESS COST WITH *Carpenter* FREE-MACHINING STAINLESS

"Big Help to Getting More Parts From Every Pound of Stainless" . . .

That is what customers say about the Carpenter "NOTEBOOK on Machining Stainless Steels" with its 96 pages of useful information on Turning, Drilling, Tapping, Threading, etc. For your copy, just drop us a note on your company letterhead. Extra copies of the NOTEBOOK, for the men in your plant, are available at 50¢ each.

3 **PRODUCTION UP 25%!**

The Plant Manager told us that he has tried many Stainless Steels, and is convinced that Carpenter Stainless No. 5 provides the best finishes and *machines 25% faster than competitive materials.*

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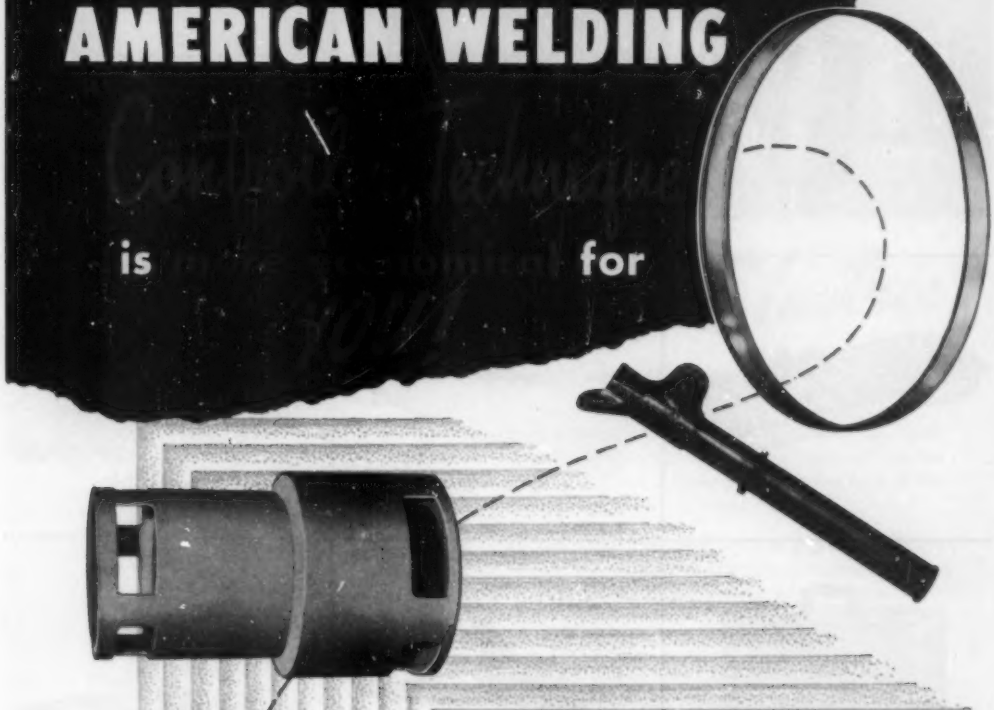

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To manufacture the products illustrated above, a *variety* of alloys and tempers of aluminum are required—each suited to the specific requirements of the job.

How about *your* product? Does it fully utilize aluminum's advantages?

A change in alloy or temper may enable you to *improve your product* by giving it:

Increased strength . . . reduced weight... improved finish... greater durability.

Furthermore, by making a change in alloy or temper you may be able to *reduce your manufacturing costs* through:

Lower material cost... fewer fabricating steps... lower rejection rate ... lower finishing costs.

Sometimes a minor change in product design—which would enable you to make use of a different alloy—will result in one or more of these benefits.

So ask yourself if you're taking fullest advantage of aluminum's remarkable versatility. If there's any doubt, call in a Kaiser Aluminum engineer and he'll give you the answer!

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Check These Advantages of Redesigning Your Product *with a...*

Lamb Electric special application MOTOR

Perhaps you will find the answer to your problem, "*How can we give our product more sales appeal?*" in the increasing practice of redesigning with the help of the Lamb Electric engineering department.

By using Lamb Electric *motor parts* or a complete *frame motor* — engineered for the *exact* requirements of your application — you may gain these advantages:

IN THE MOTOR...

1. Reduced cost, weight, space.
2. Exact mechanical and electrical characteristics.
3. Thorough dependability.

IN THE PRODUCT...

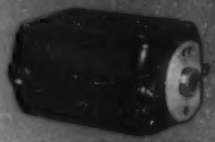
4. Better performance.
5. Improved eye-appeal.
6. Compactness, less weight.

Our engineering department will be glad to team up with yours to help achieve these results.

The Lamb Electric Company, Kent, Ohio.

Universal motor parts widely used in small portable electric tools, sewing machines, and hand vacuum cleaners.

Compensated series unbanded motor parts used on heavy-duty applications such as chain and circular saws and pipe threaders.

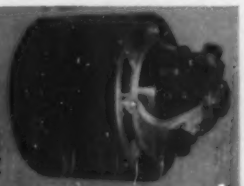


A compact motor particularly suitable for computing machines and other types of motor-driven office equipment.

Typical applications for this motor: industrial vacuum cleaners, agitators, mixers, and colloid mills.

Universal motor with shaft carried on double row ball bearings; developed for use as a high-speed grinder.

Compactly designed turbine . . . driven by a high-speed series motor . . . particularly adaptable to the canister-type vacuum cleaner.



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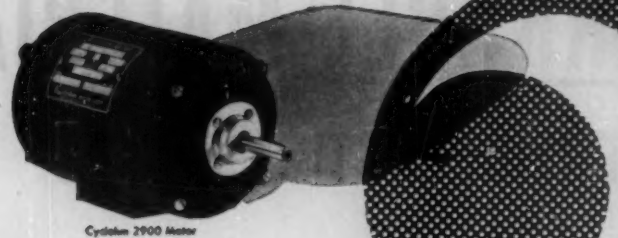

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adaptability...

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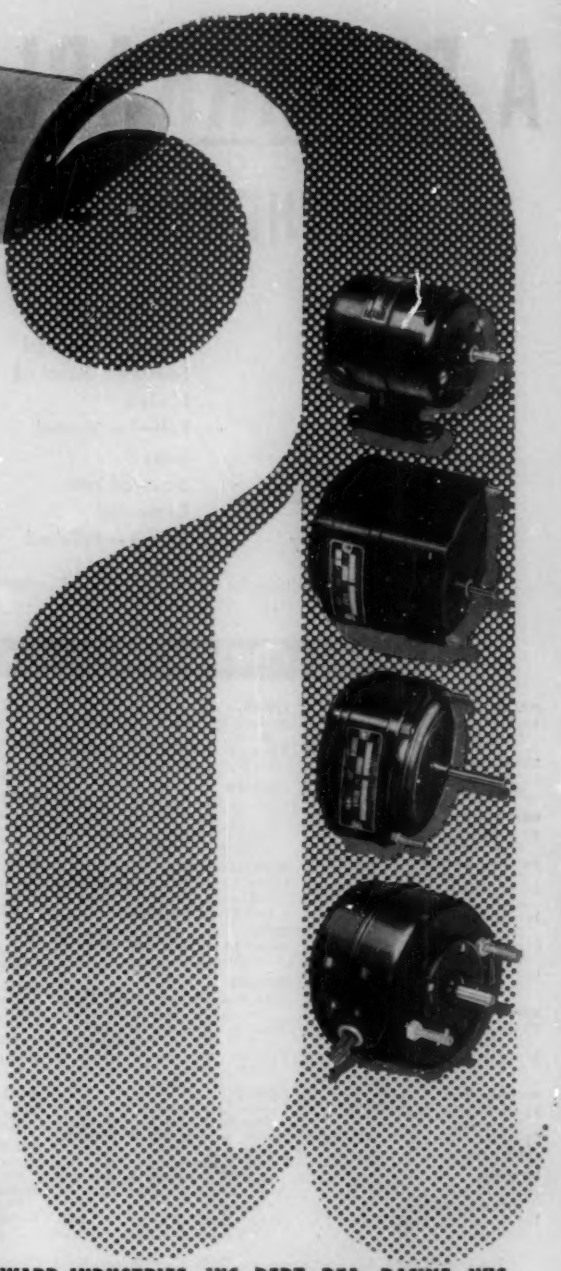

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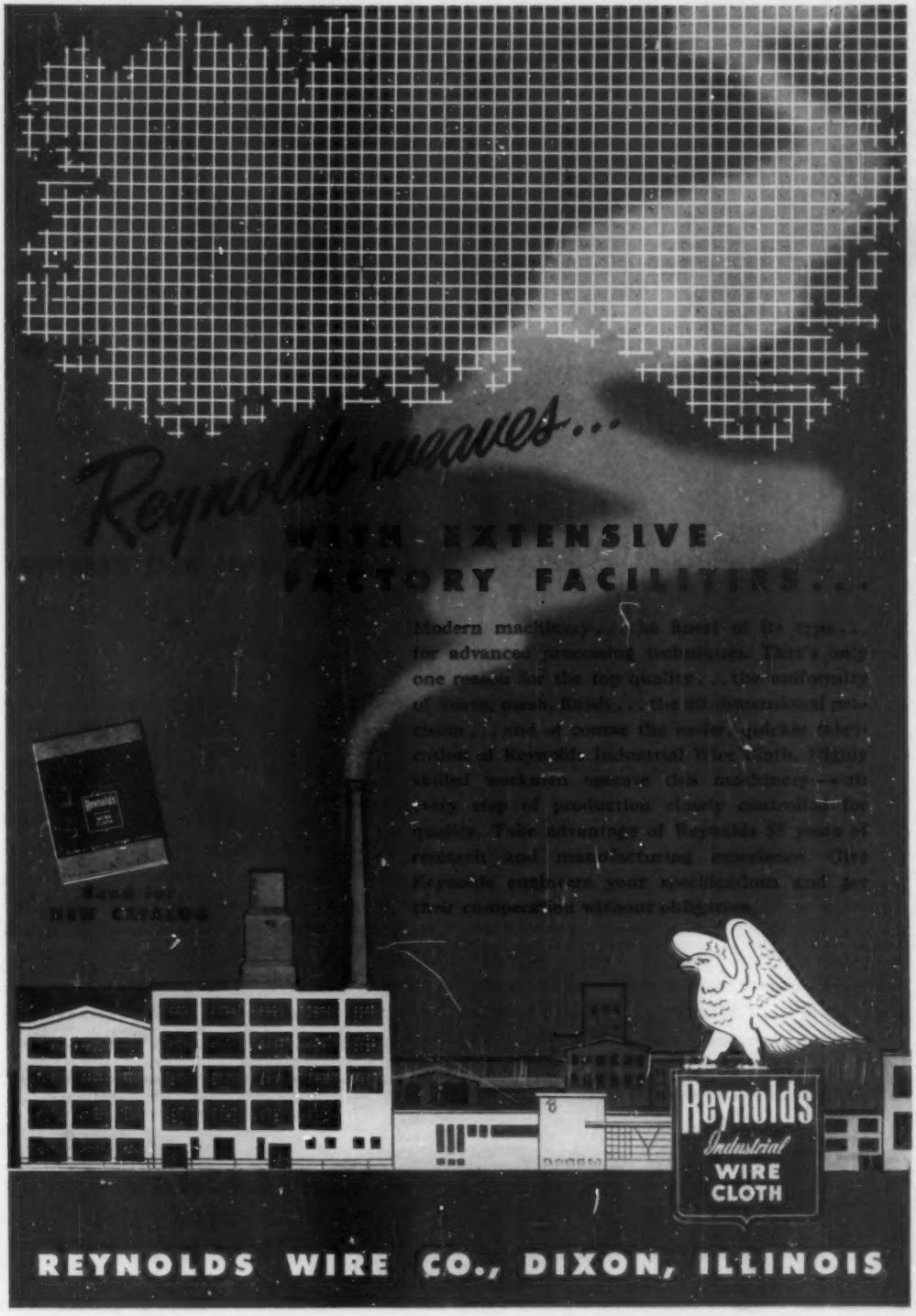
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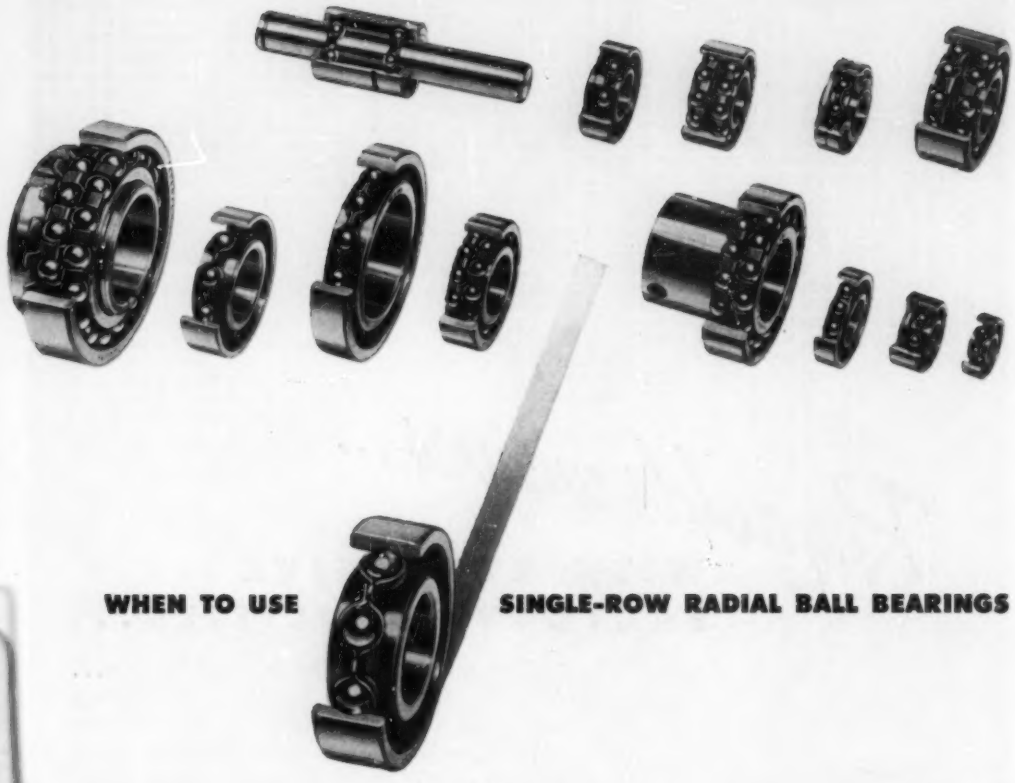

WHEN TO USE SINGLE-ROW RADIAL BALL BEARINGS

Combined thrust and radial loads in any proportion or direction call for deep, continuous races and the largest ball consistent with uniformly heavy ring sections...the kind of precision bearing construction Federal Single-Row Radial Ball Bearings give you.

In Federals, maximum unit pressure per ball is not appreciably increased by the addition of thrust loads up to 50% of the rated radial load. Thrust load is distributed over all the balls in the bearing, while radial load is carried by less than half the balls. For pure thrust the rating is 100% of the radial rating.

Federal Single-Row Radial Ball Bearings are made in light, medium and heavy series, in inch and metric sizes, to cover a wide range of applications. Our Catalog "K" describes these and one of the most complete lines of ball bearings...in every type and size...shielded and sealed...for every anti-friction need. (A few of the many types are illustrated above.) It also includes ball bearing selection charts to help you compute bearing loads, determine load ratings for all bearings at all speeds, and select the type and size bearing best suited to your application. Write for it today.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT
2640 Book Tower, Detroit 26, Mich. • 8 So. Michigan Ave., Chicago 3, Ill.
Chester-Twelfth Building, Cleveland 15, Ohio

Quality since 1908

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Looking for BIG savings on bellows assemblies?

See how we can help you!

IF you're looking for ways to cut costs – and hold to quality standards on bellows assemblies – check with Fulton Sylphon or Bridgeport Thermostat.

You'll save production problems and worries, because we can take over the entire job. Assemblies in stainless steel, brass or other metals will be made exactly to your specifications.

You'll save time, because you'll get the assemblies you need *on schedule*. We can take care of orders in any volume.

You'll save overhead costs, because we have the trained personnel–complete equipment–an expert engineering staff.

What's more, no matter how complex an assembly you require, we can produce it as you want it. Designing and making bellows assemblies is our specialty. We've been doing it successfully for nearly half a century. And we'll work with you on special developments, confidentially if you wish.

Hundreds of thousands of Sylphon bellows assemblies are serving dependably day in and day out in scores of ways. For example – in thermostatic devices, pressure controls, hydraulic mechanisms, valves, shaft seals, recording instruments and other applications.

Find out how you can make important, all-around savings on your bellows or bellows assemblies needs. Write for information. Ask for idea-packed, free catalog AP-1200.

TEMPERATURE CONTROLS

FULTON SYLPHON DIVISION
Knoxville 4, Tenn.

Robertshaw-Fulton CONTROLS COMPANY

BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT DIVISION
Bridgeport 1, Conn.

from torque to tobacco...

via

R/M

FIRST IN FRICTION

Tobacco growers, wheat growers, corn growers . . . farmers of every kind . . . applaud the newest development in farm mechanization: *the tractor with a torque-convertor*. As you might expect, R/M has played a big part in perfecting this new use of a new principle in clutches. Here's still another reason why industry looks to R/M, the world's largest producer of friction materials, for practical solutions to problems in brake linings and clutch facings!

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION **620 Fisher Bldg., Detroit 2, Mich.**

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Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C.

R/M

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

of the Brass Rod Industry

the standard of comparison!

There is a difference in brass rod—A BIG DIFFERENCE.

Some mill men say there is no difference in FREE CUTTING Brass Rod made by different Brass Mills. They reason that since all mills use the same class of raw materials, the same type of equipment, and in addition, since all are controlled by well-equipped laboratories and technical departments, the product must be the same.

However, the men who actually operate the machines at rod consuming shops, who buy rod from more than one mill and who are really in a position to make true comparisons say, "THERE IS A DECIDED DIFFERENCE." Many of these consumers operate their machines on the same parts for long periods, and gradually the product of one particular mill BECOMES THE STANDARD OF COMPARISON for BRASS ROD of all mills.

Mueller Brass Co. Red Tip FREE CUTTING Brass Rod is the yardstick with many of the largest rod consumers, and since it enjoys this rating, it is usually selected for the tough jobs.

We have the "know-how" to produce the best in Brass Rod for any purpose. If you want it for long runs where special properties are required, our Technical and Metallurgical engineers are at your disposal. Worthwhile savings can be made.

Millions of pounds of brass rod are manufactured in our mill each month. Shipment can be made at once from our large factory stocks.

YOU CAN PIN MORE PROFIT TO YOUR COST SHEETS!

Mueller Brass Co. Red Tip Brass Rod is a universal, many-purpose, extra-fast cutting Rod. Its constant uniformity saves tools, grinding and setup time. It actually can be machined at greater speeds than that of which any machine is capable on a continuous production basis.

YOU CAN PIN MORE PROFIT TO YOUR COST SHEET BY USING MUELLER BRASS CO. RED TIP.

MUELLER BRASS CO.

PORT HURON • MICHIGAN

STREAMLINE PRODUCTS

ASK STOKES

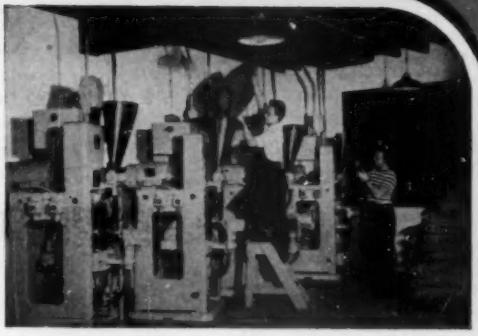
Therm-O-Disc Casings Designed for Savings

THERM-O-DISC, Incorporated, Mansfield, Ohio, designed the plastic casings for their various thermostats for production on Stokes completely automatic molding machines.

Identical plastic casings . . . accurate in dimensions, low in flash loss, and of highest quality . . . are produced on these fully automatic presses.

Low labor and mold costs, high output, and controlled inventories are additional advantages. Automatic molding is the most profitable way to make a wide variety of electrical plastic components.

You can quickly learn if your electrical parts can be designed for high-speed, low cost automatic molding. Samples or parts blueprints sent to Stokes Advisory Service bring cost estimates and recommendations, without obligation.



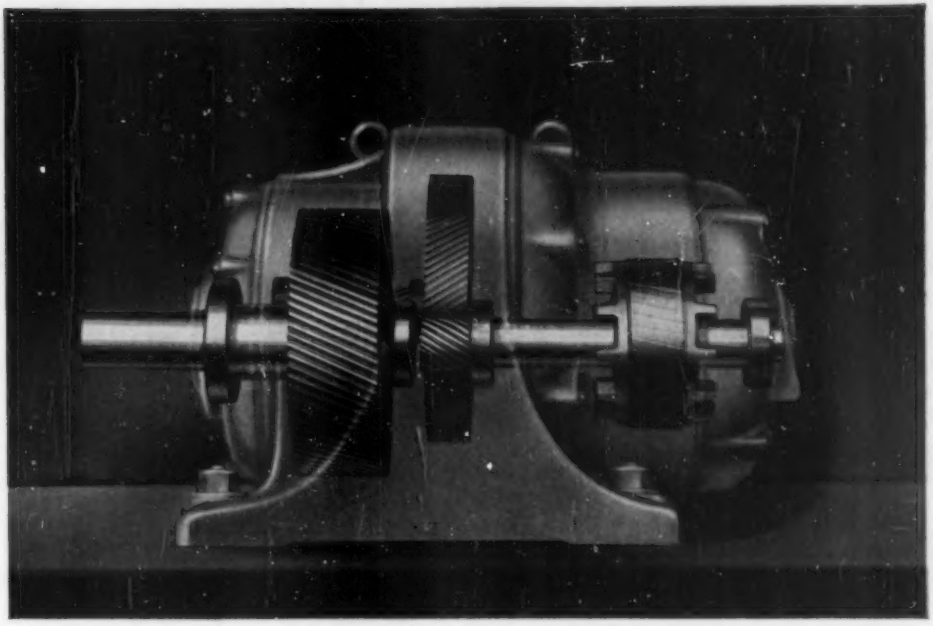
F. J. STOKES MACHINE CO.
5900 TABOR ROAD
PHILADELPHIA 20, PA.

FJS

Stokes makes Semi-Automatic and Automatic Molding Presses, Plunger Presses, Closure Presses, Preforming Presses, Industrial Tabletting and Powder Metal Presses, Vacuum and Special Processing Equipment, Water Stills and Special Machinery.

STOKES KNOWS HOW

U. S. SYNCROGEAR MOTOR



Diaphanous view of U. S. Syncrogear Motor.

THE GEARED MOTOR WITH PYRAMIDAL STABILITY

DEPENDABILITY

Rugged pyramidal base withstands external stresses. Hardened gears are designed for high safety factor. Lubrication is positive.

ECONOMICAL OPERATION

Helical gears and full anti-friction bearings contribute to high efficiency. No rubbing seals to wear and cause leakage.

LONG LIFE

Gears are hardened to 45/50 Rockwell C. All motor windings are asbestos protected. Normalized castings maintain accuracy.

COMPACTNESS

Integral design eliminates couplings. High speed motor for efficient power conversion. Solid shank pinion permits greater ratio.

QUIET OPERATION

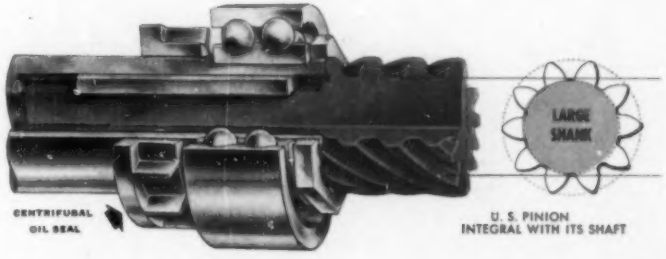
Simple helical gear trains, precision finished, are permanently held in alignment. Low pitch line velocities are used.

MANY TYPES AND SIZES

Single, double, and triple reductions are available in sizes of ¼ to 30 h.p. and standard AGMA speeds of 10 to 10,000 RPM.

U. S. SOLID SHANK PINION

The vital high speed pinion in Syncrogears is integral with its shaft; therefore cannot vibrate or work loose. Its solid, oversize diameter reduces deflection to almost one-half that of the ordinary type. The motor shaft is bored hollow to receive the pinion. Maximum strength is obtained by this advanced design.



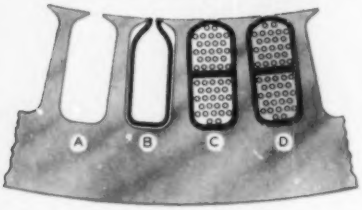
See next page

Type GR—Single Reduction Syncrogear

U.S. MOTORS.

ASBESTOS PROTECTION

PREVENTS CARBONIZATION



Life of a motor is proportional to life of the insulation protecting the windings. All U. S. Motors are asbestos-protected. Asbestos cannot carbonize. The windings are insulated with asbestos and electrically impregnated with Asbestosite. Each wire is insulated with asbestos. Above drawing shows the progressive steps in insulation. (A) empty stator slot; (B) formed cell of asbestos heatproof wall; (C) wires inserted within asbestos enclosures; (D) Asbestosite forced around each wire.

NORMALIZED CASTINGS

HEAT-SEASONED FOR ACCURACY

All fine precision parts such as those used in giant telescopes, artillery guns, gears, angle blocks and surface plates are invariably normalized. So likewise are U. S. Motor parts.

Heat-seasoning by the U. S. normalizing process *stabilizes the molecular structure* of castings. By removing internal stresses before a cast iron part is machined, endurance and accuracy are forever assured. Every part of the motor maintains its original precision throughout its life. U. S. normalized castings are more costly to produce than ordinary castings, but the sustained efficiency and prolonged motor life thus induced, more than justify the added expense. Life-long durability is *assured.*

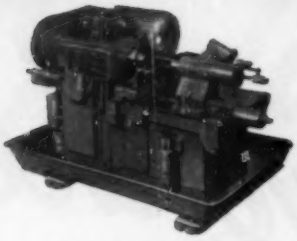
For ever-dependable geared power, install the U. S. Syncrogear. Its accuracy of parts and perfection of hardened gears earn greatest operating economy.

U. S. castings undergoing normalization. Permanent alignment of gears and bearings is thereby assured. This is an added plus value in every U. S. Motor.

Write for new illustrated, descriptive Bulletin

U.S. ELECTRICAL MOTORS Inc.

ATLANTIC PLANT: Milford, Conn. • PACIFIC PLANT: Los Angeles 54, Calif.
District Offices: Boston 16, New York 6, Philadelphia 2, Pittsburgh 22,
Chicago 8, San Francisco 7, Seattle 4



VARI-PITCH AUTOMATIC SHEAVE AND TEXROPE DRIVE

broadens Application of Gisholt No. 12 Hydraulic Automatic Lathe

Speed Problem Solved!

GISHOLT MACHINE COMPANY had this problem. One of their customers specified an ultra-fine finish when machining various size piston rings which could only be obtained through *stepless adjustable* spindle speed.

Gisholt found the solution in the use of an Automatic *Vari-Pitch* Sheave (5½ in. to 10 in. pitch diameter) and a 14 in. pitch diameter companion sheave.

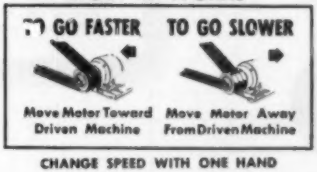
This combination gave them *exactly* the required speeds with instantaneous, simple handwheel adjustment. And because the Automatic *Vari-Pitch* Sheave and drive fitted in the small space, no major changes in design were necessary!

WIDE APPLICATION

Automatic *Vari-Pitch* Sheaves can replace almost any standard sheave on drives from 1½ to 40 hp (special to 60 hp) . . . will give you *stepless* speed changes in a matter of *seconds*... overall speed ratios of as high as 2 to 1.

Many designers have already adopted these new sheaves for use on textile spinning frames, centrifugal pumps, farm machinery, various machine tools, and hundreds of other products.

HOW IT WORKS



CHANGE SPEED WITH ONE HAND WHILE MOTOR IS RUNNING

For complete information on diameters and number of grooves, check No. 1 in the coupon below.

ALLIS-CHALMERS, 1002A SO. 70 ST, MILWAUKEE, WIS.

Please send me the literature checked below:

- ☐ 1. *Vari-Pitch* Automatic Sheaves — Section 20-P-50 (Part 4)
- ☐ 2. Handy Guide for Quick Selection of standard Texrope Drives — Bulletin (2086051)

Name

Title

Firm

Address

City State

A-2920

Vari-Pitch and *Texrope* are Allis-Chalmers trademarks.

ALLIS-CHALMERS

ORIGINATORS OF THE MULTIPLE V-BELT DRIVE FOR INDUSTRY

Consider the

BEFORE YOU CHOOSE POWER TRANSMISSION, TIMING AND CONVEYING EQUIPMENT

When you are facing today's most pressing problem, designing for lower costs, it's important to consider carefully the conditions under which your power transmission, timing or conveying equipment must operate.

Slow speeds, high speeds, light loads, heavy loads, long centers, short centers, heat, dust, corrosion, abrasion, these are the factors that should determine your choice. From the standpoint of first cost and operating cost to your customers, the medium selected must meet the conditions.

There is no one best or stock answer. That is why we at Chain Belt Company feel that we can be of practical assistance to you in cutting costs . . . improving product performance. Because we manufacture *a complete line of chains*, we can help you select the chain that is exactly right for your machines. Our Field Sales Engineers are not limited to a single type of chain. They can recommend, without prejudice, the chain that will stand up. Conversely, they can recommend a lighter chain, if your designs are overchained, with important cost advantages to you. Our Field Sales Engineers will be happy to assist you in reviewing your chain selections. Call or write the Chain Belt Field Sales Office near you or, if you prefer, mail the coupon below.

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CHAIN BELT COMPANY

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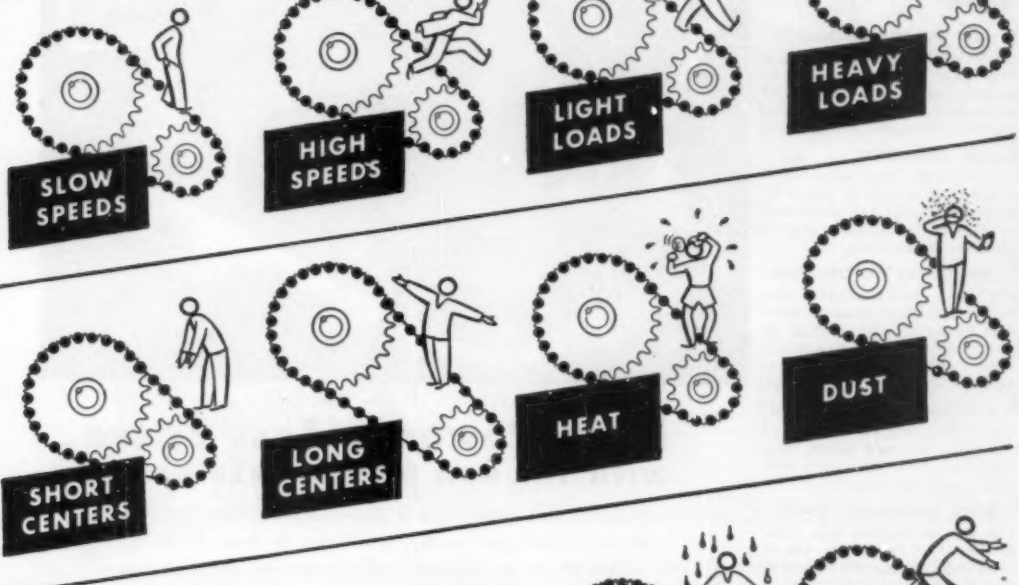

THE COMPLETE CHAIN BELT LINE

Baldwin-Rex Roller Chains
Baldwin-Rex Double Pitch Roller Chains
Baldwin-Rex CPS Flat Top Chains
Rex Cast & Steel Detachable Chains
Rex Pintle Chains
Rex H-Type Drive Chains
Rex H-Type Conveyor Chains
Rex Refuse & Log Haul Chains
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Rex Duraber Chains
Rex Cast Roller Chains
Rex Double-Flex Chains
Rex Sugar Mill Chains
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Rex Offset Side Bar Roller Chains
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Rex Cast Sprockets
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Baldwin-Rex Flexible Coupling and a complete line of chain attachments.

BALDWIN-REX

Chain Belt Company
1715 West Bruce Street, Milwaukee 4, Wisconsin

Gentlemen:
I am particularly interested in.....
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( ) Please send me descriptive bulletins.
( ) I would like to have a Field Sales Engineer call on me regarding my chain application problems.

Name.....
Company.....Department.....
Address.....
City.....State.....

8 reasons why you should choose Maxi-Power Drives

1. HIGH QUALITY GEARING
Alloy steel gears and pinions with gear teeth generated to greater accuracy. Improved methods of heat-treating give increased strength—longer life.

2. HIGH EFFICIENCY
Antifriction bearings—improved accuracy of gears—maintained accurate alignment—effective lubrication assures operating efficiencies.

3. DEPENDABLE PERFORMANCE
Improved design, rugged construction, highest quality materials, accurate manufacture to close tolerances, all assure extreme ruggedness for heavy-duty service over long periods.

4. SMOOTH QUIET OPERATION
The overlapping tooth action of extremely accurate gears, plus close back lash tolerances, provides quiet operation.

5. MORE POWER—LESS SPACE
The careful engineering, quality manufacture and the use of finest materials permit the selection of a smaller size unit than was previously necessary.

6. POSITIVE LUBRICATION
All gears and bearings are lubricated from a large oil reservoir by a simple, efficient system.

7. OIL-TIGHT CONSTRUCTION
Oil seals at all shaft extensions provide oil-tight construction—clean operation.

8. SIZES AND RATIOS
Single, double, and triple units in a range of 42 sizes. Standard ratios from 2.08 to 1 up to 360 to 1 h.p. up to 1350.

More Power in Less Space
WITH THE NEW MAXI-POWER DRIVES

High quality, rugged dependability characterize this new line of enclosed helical gear drives—Maxi-Power by Foote Bros.

These drives are available in single, double, and triple reductions in a wide range of sizes and ratios.

Write today for a copy of the Maxi-Power Bulletin or call Foote Bros'. representative in your city.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 S. Western Blvd. • Chicago 9, Ill.

FOOTE BROS.

Better Power Transmission Through Better Gears

A COMPLETE LINE OF HIGH-QUALITY ENCLOSED GEAR DRIVES

HYPOWER VERTICAL · HYGRADE HORIZONTAL · HYGRADE HYTOP · WORM-HELICAL DRIVES · FOOTE BROS.-LOUIS ALLIS GEARMOTORS · LINE-O-POWER DRIVES

Loosened set screws are a frequent cause of machine failure. When such failure occurs in important production machinery it can be expensive indeed—in downtime, repair costs, lowered production, poor deliveries and loss of customer good will.

Fortunately, the expense and headaches of this kind of machine failure can be eliminated by simply using UNBRAKO Self-Locking Set Screws, the only socket set screws with the famous "*money-saving*" knurled points.

The unique, counterclockwise knurls on the UNBRAKO point make the screw exceptionally vibration-resistant, prevent "creep" and subsequent loosening. The UNBRAKO "stays put", even under the most chattering vibration. IT WON'T SHAKE LOOSE!

Think of the advantages of such "Vibration Insurance" for your production machinery! And remember, it makes an impressive selling point when you use UNBRAKO Self-Locking Set Screws on your finished products.

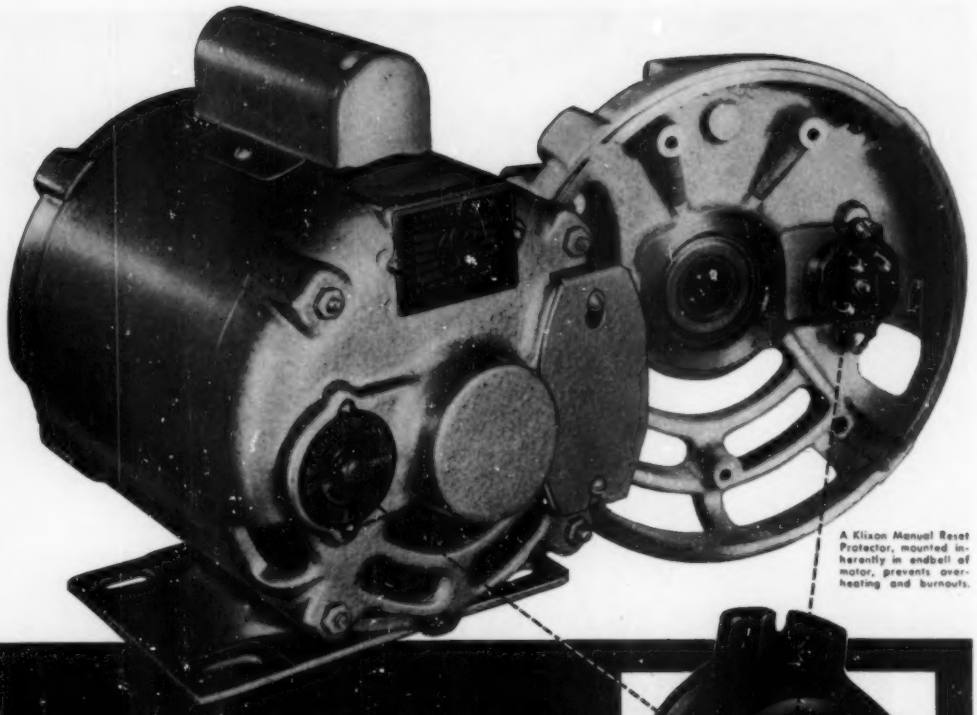
Our folder 658 gives you further details. Write for your copy today.

SOCKET UNBRAKO SCREWS

SPS STANDARD PRESSED STEEL CO.

BOX 545 JENKINTOWN, PENNSYLVANIA

"UNBRAKO Counts With The Men Who Count"



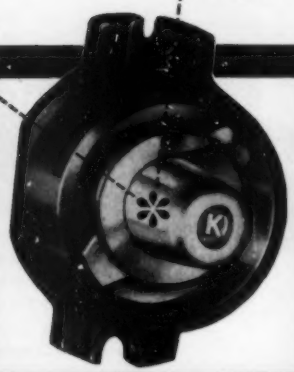
A Klixon Manual Reset Protector, mounted inherently in endbell of motor, prevents overheating and burnouts.

"Burnout From Overloading or Overheating...

NOT THIS MOTOR,

It's Permanently Protected with a

KLIXON PROTECTOR"



Illustrated above, is a picture of a motor that won't burn out from overloading or overheating. The reason — it's protected from these motor destroyers by a Klixon Protector.

Built-in as an inherent part by the motor manufacturer, the Klixon Protector safeguards the motor by cutting "off" the power just before it becomes dangerously overheated. Then when it cools to a safe operating temperature, it snaps the power "on" again on the manual reset types when the red button is pushed; and automatically on the automatic reset types. Temporary overloads do not cause nuisance tripouts.

Regardless of the motor driven product you make, from oil burners to machine tools, it will pay you to specify and insist that your motor manufacturer supplies you with motors protected with Klixon Protectors. They'll keep your equipment operating by reducing motor burnouts... save you money by minimizing motor repairs and replacements.

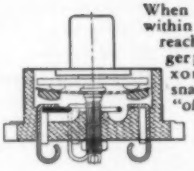
Remember, too, Klixon Protectors in transformers, solenoids, variable voltage transformers and other electrical equipment keep them from burning out.

SPENCER THERMOSTAT
Division of Metals and Controls Corp.
901 FOREST ST., ATTLEBORO, MASS.

KLIXON

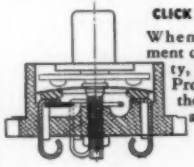
HERE'S HOW IT PROTECTS

CLICK... IT'S OFF!



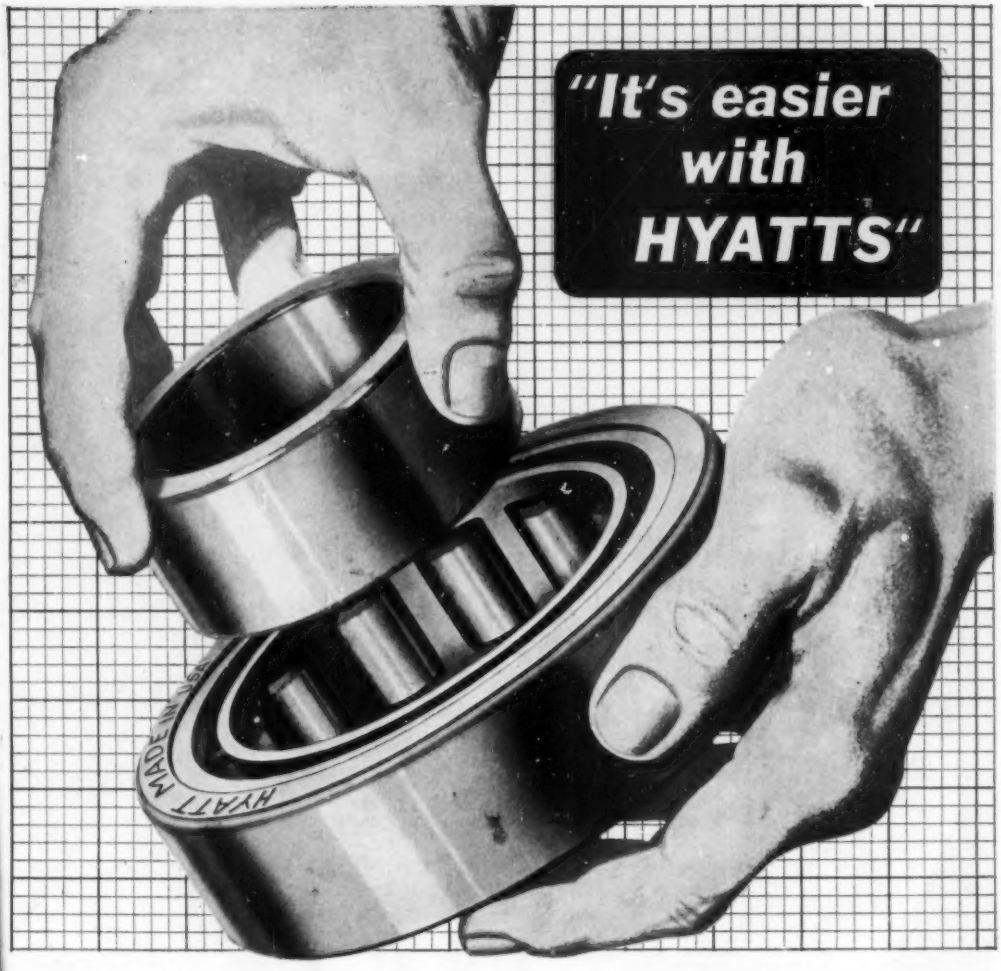
When temperature within the dome reaches the danger point, the Klixon Protector snaps the power "off" preventing burnouts.

CLICK... IT'S ON!



When the equipment cools to safety, the Klixon Protector snaps the power "on" automatically.

WE
WELCOME
SMALL
ORDERS
B
B



Because all separable parts are interchangeable

Any inner race or outer race will fit any roller assembly of the same piece number. This eliminates selective fitting and permits you to assemble the separable bearing parts in different machine elements and then bring the elements together, fully confident that all bearing parts will match.

Add to this the fact that Hyatt Hy-Load Roller Bearings are available in a full range of sizes and ten major types, and you have some idea of the wide flexibility of product design and assembly procedures made possible by the use of Hyatts.

• • •

If you are designing something new, or redesigning an existing product, reach for a Hyatt catalog and see for yourself why "It is easier with Hyatts." Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

There is No Substitute for Quality
For Small Industrial, Outboard and Marine Engines
Specify
BENDIX-SCINTILLA
THE MOST TRUSTED NAME IN MAGNETOS

It is only good business to insist on quality in any product because quality can mean the difference between successful performance or failure. Quality in your engine magnetos is particularly important because without constant, full voltage sparks peak performance is unobtainable. Years of dependable performance in the field of aircraft ignition has won for Bendix-Scintilla the reputation as the most trusted name in magnetos. This broad background of experience and dependability is reflected in the ultimate—compact, lightweight magnetos now available for small industrial, outboard and marine engines. Since there is no substitute for quality, be assured of the best by specifying Bendix-Scintilla.

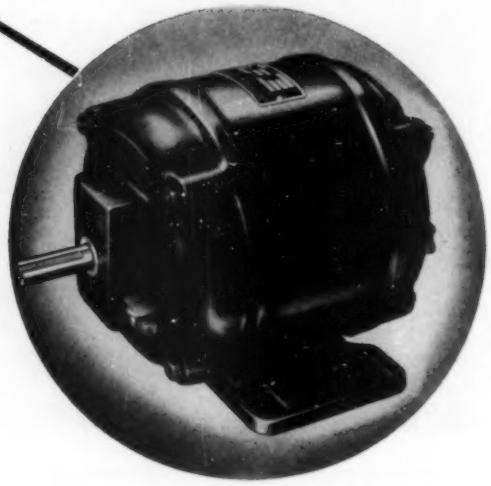
BUILT-IN RELIABILITY

Simplicity in design • Waterproof condenser and coil • Lower operating cost • Minimum lubrication requirements • Light in weight • Higher voltage at starting speeds • Constant spark over entire speed range • Compact and sturdy construction.

BENDIX SCINTILLA SCINTILLA MAGNETO DIVISION of

HOLTZER CABOT

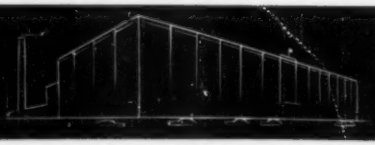
DEPENDABLE MOTORS FOR DEMANDING APPLICATIONS



SIZES UP TO ONE HORSEPOWER

Manufacturers with motor application problems keep turning to Holtzer-Cabot —*and they get the answers!* Continuous duty motors . . . synchronous or induction, split phase or capacitor start . . . Holtzer-Cabot motors are available in a variety of types from the small instrument sizes up to heavy duty one horsepower units. Here are motors built for exacting requirements. In applications such as office and recording machinery, blower units, hoists, machine tools, fans, pumps and farm equipment, Holtzer-Cabot precision made motors have been proven in use by world famous manufacturers. Write or phone today for complete information.

• BUILDERS OF FINE ELECTRIC MOTORS FOR THREE-QUARTERS OF A CENTURY



HOLTZER-CABOT DIVISION OF NATIONAL PNEUMATIC CO., INC.
BOSTON 19, MASSACHUSETTS
OFFICES IN NEW YORK, PHILADELPHIA and CHICAGO

G.S. Ratchets bring Accuracy and Long Life to CLARE Stepping Switches

THE new Clare Stepping Switch is a beautiful example of precision engineering . . it has a ***minimum*** life of five million half-revolutions or 130 million stepping operations! To assure the long life and amazing accuracy of this mechanism, Ratchets by G.S. are an important integral part. They help to bring high standards of quality and efficiency demanded for this intricate device. Chances are G.S. can make an important contribution to the dependability, long life, and perfect performance of your products. Suggestions, ideas, and cost estimates will not obligate you. Write or phone us, today!

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GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

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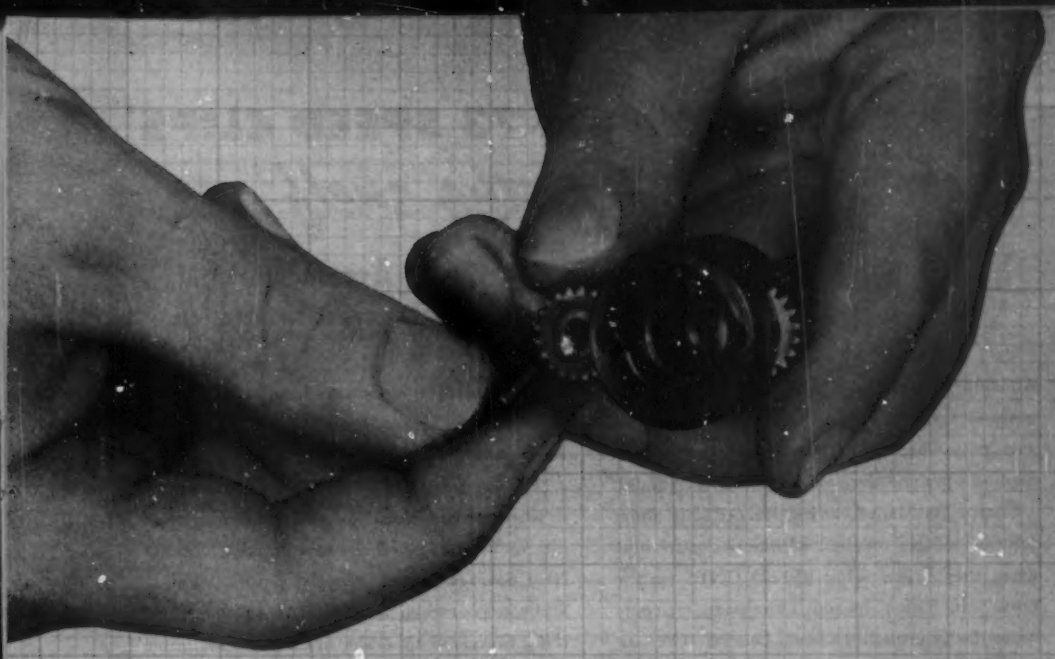

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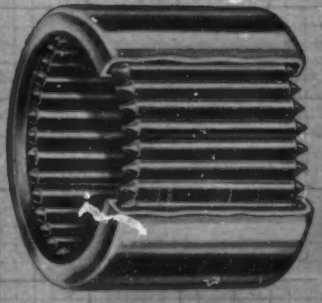

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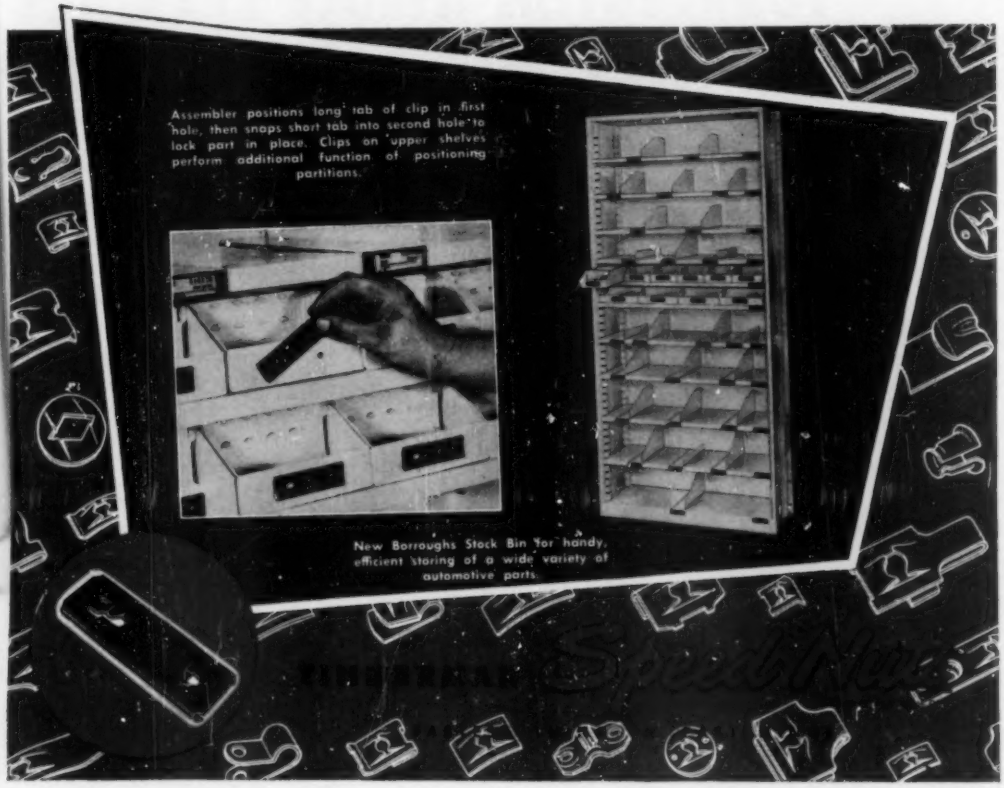

Assembler positions long tab of clip in first hole, then snaps short tab into second hole to lock part in place. Clips on upper shelves perform additional function of positioning partitions.
New Borroughs Stock Bin for handy, efficient storing of a wide variety of automotive parts.

Mack Was A Salesman

MACK WAS A SALESMAN ONLY, just as so many salesmen are. Indeed he boasted that he did not know how the product was made or much about it. But the railroad men to whom he was trying to sell an initial order of 150 headlights equipped with glass reflectors were skeptical. They insisted that Mack take the reflector out of its mounting so that they could look it over more thoroughly. Naturally, he had no idea how that glass reflector could be taken out. But he saw some screws that obviously held the mounting ring and, using a borrowed screw driver, after many slips and twists he finally succeeded in getting out the reflector. He passed it around, holding it very gingerly and talking fast about its wonderful scratch resistance and optical qualities. He carefully avoided any mention of possible breakage.

The railroad men shook their heads. Perhaps it was a better reflector, they admitted, but it was glass and everybody knows glass breaks easily. Now, if it were not for that they surely would give him the order.

Gingerly but clumsily Mack started to replace the glass reflector, putting the screws wherever they would fit. Suddenly the screw driver slipped and bang went the screw driver and Mack's fist into the glass reflector standing precariously near the edge of the desk. Down on to the linoleum floor fell the reflector, bounced twice and then came to rest, whole and undamaged. Just a lucky hit.

Mack was a salesman. In spite of his surprise, which almost stunned him, he quickly said, "Well gentlemen, I am sure no roundhouse men would give it rougher treatment. What more proof would you want. This special glass is sure tough." Mack got the order.

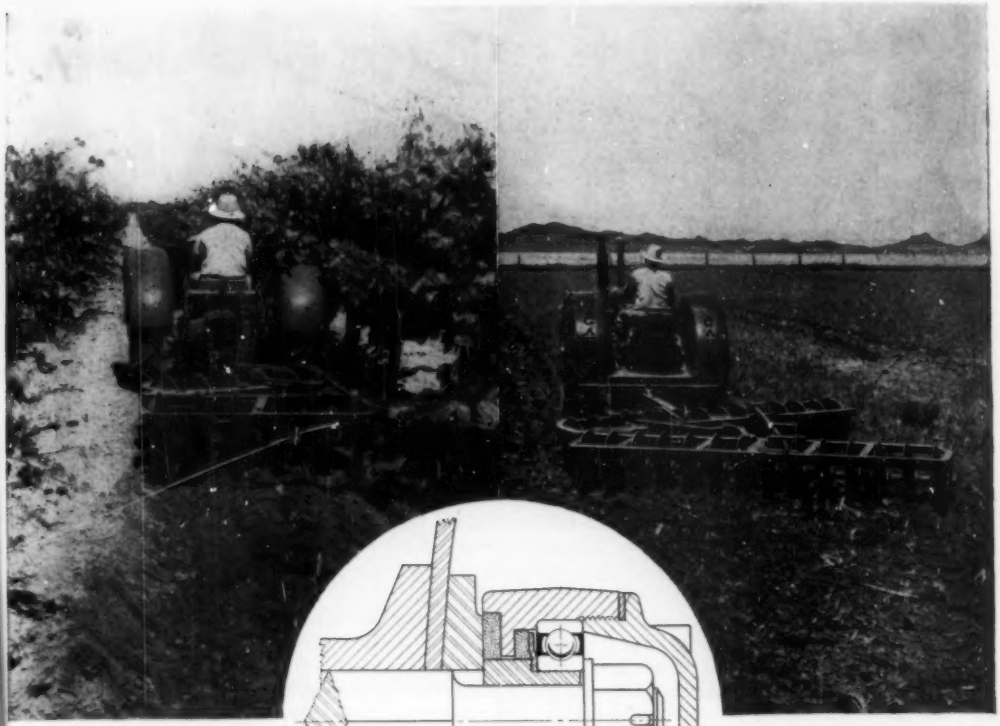
This proves that Mack had the dumb luck of an Irishman that he was. It also illustrates the fact that only too often the salesman knows so little about his product that he lacks faith in it. Had Mack disassembled the lamp and handled the reflector in the normally rough fashion that the men in the assembly department did, the railroad men probably would not have gotten the impression that the reflector was fragile.

Most manufacturing companies know the value of training their salesmen in the construction and merits of their product. In many companies the head of engineering is not only given the opportunity but is required to demonstrate to the sales department the commercial merits of the design and its construction. This, of course, implies that the engineering department is kept informed about sales promotion and salesmen's activities.

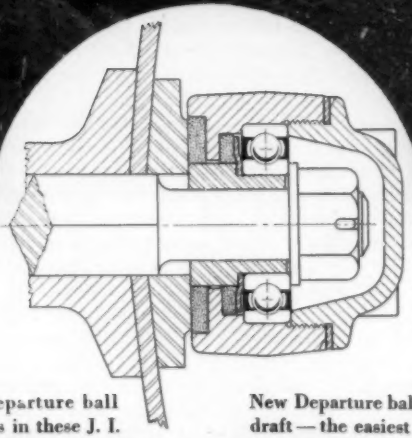
The engineering executives should be treated on the par with the sales executives, rather than being looked upon as the handmaidens to be called upon as a service organization when the sales department is stumped. And salesmen should be required to know the product they are selling.

G. F. Rodenbolt

WORKERS YOU DON'T HAVE TO FEED



Case "VA" Tractor and "CO" Offset Disk Harrow working in a California vineyard.



Case Model "LA" Tractor pulling a Case "CO" Offset Disk Harrow in Arizona.

THE free running New Departure ball bearings supporting the disks in these J. I. Case Offset Disk Harrows don't require any more attention than the wheel bearings of automobiles. You don't have to make any adjustments or feed them any lubricant because they are thoroughly sealed to keep grease in and dirt out.

New Departure ball bearings provide the lightest draft — the easiest turning disks, combined with the most positive, dependable support it is possible to build into a disk harrow. Each bearing housing is carried on trunnions to assure that no misalignment can interfere with this free operation.

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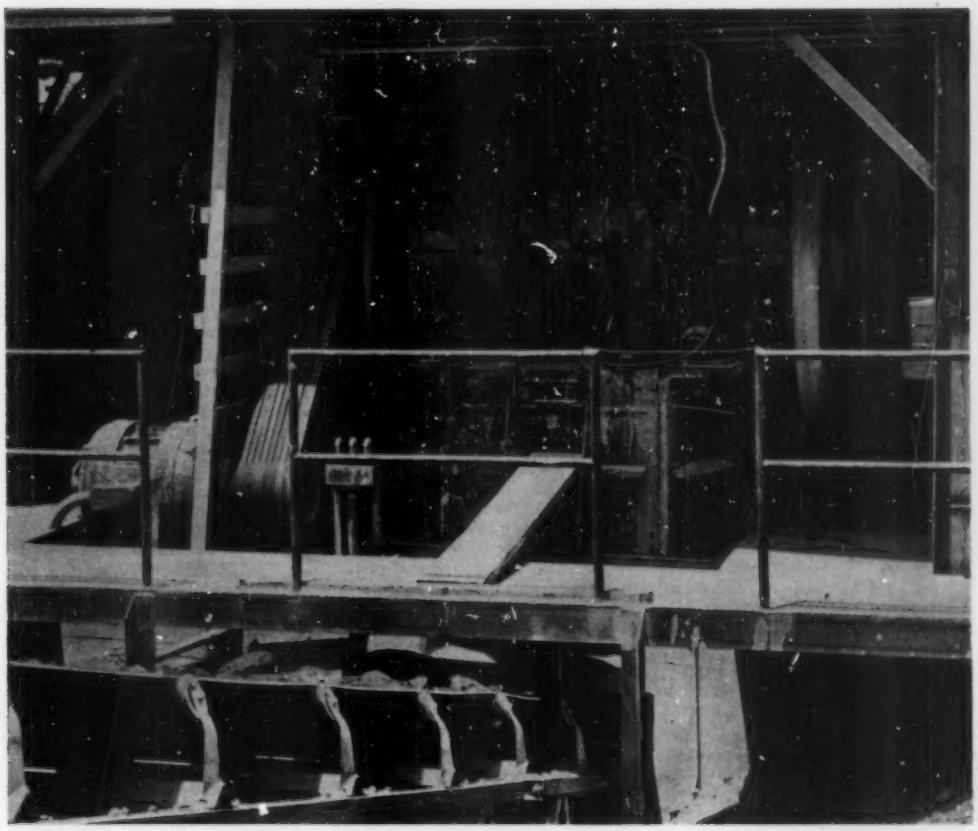

THIS JAW TYPE ORE CRUSHER, 42 x 32 in., characterizes a load of type 2(a). It is not economically practical to furnish a drive heavy enough to start a crusher jammed with huge rocks, consequently crushers like this must be unloaded before starting.

Torque Requirements Of Large Motor Driven Loads

G. BYBERG and E. H. FREDRICK
Motor-Generator Section, Electrical Department
Allis-Chalmers Manufacturing Company

TO SOLVE ANY MOTOR APPLICATION problem correctly, the characteristics of the driven load must be as thoroughly understood as the performance characteristics of the different types of motors that might be applicable.

Starting with simple fundamentals, a motor is basically a torque-producing device. Torque, or twisting effort, is ordinarily expressed in terms of pounds at a one-foot radius by equation

$$T = \frac{\text{hp} \times 33{,}000}{2\pi \times \text{rpm}} \qquad (1)$$

Yet when motors are purchased, the rating is generally specified in terms of horsepower and rpm. And while torque requirements are occasionally specified, in the majority of cases, only the type of driven machine is given. The motor manufacturer then determines the proper torque characteristics required of the motor.

Horsepower rating alone usually is not the right means of specifying the motor. The horsepower rating of a motor is indicative only of its torque at rated speed and, for irregular load cycles or pulsating loads, of the rms

value of horsepower that can be developed without exceeding rated temperature rise of the motor.

With alternating current motors, and particularly synchronous motors, the horsepower rating alone is by no means a definite indication of the suitability of the motor for any particular drive. There are many applications where a motor may be perfectly capable of driving a given load after that load has been accelerated to full speed, but the motor may not have sufficient static torque to break the driven machine from rest, or it may be entirely unsuitable for accelerating it.

Hence, for many machines, the torque is the determining factor in selecting the motor.

To better understand the importance of torque requirements, it is necessary to consider the work to be done by the driven machine. The mechanical work done is the scalar product of the force acting on a body, multiplied by the linear distance through which the point of application moves. The fundamental purpose of any machine is to perform one of the following functions:

1. To move or displace liquids or solids.

2. To compress or evacuate gases.

3. To lift, convey, crush, grind or pulverize solids.

4. To roll, plane, cut, shape or extrude metals or other solids.

In any of the above types of work, the driven machines, as far as torques are concerned, may be placed in three general categories:

1. Induced action—as in centrifugal devices, where the liquid or gas being moved "slips" with respect to the motivating element and where the torque is an exponential function of the speed. (Variable Torque).

2. Positive or direct action—where a definite amount of material is moved or displaced, in direct proportion to the linear motion of the machine. The torque then remains constant regardless of speed. (Constant Torque).

3. Regulated feed of material—where the torque required varies inversely with the speed. For example, in a metal-rolling mill the reduction per pass is varied in proportion to the speed. (Constant Horsepower).

Before proceeding to a further breakdown of load torque requirements, into smaller groups of categories, the definitions (from NEMA Standards) of the kinds of motor torques that require consideration should be reviewed.

Full-Load Torque—this is the motor torque necessary to produce the motor's rated horsepower at full-load speed. In pounds at one-foot radius, it is equal to the horsepower times 5,252 divided by the full-load speed.

Locked-Rotor Torque — (Static Torque)—for an alternating current motor this is the minimum torque that it will develop at rest for all angular positions of the motor, with rated voltage applied at rated frequency.

Pull-up Torque—for an alternating current motor this is the minimum external torque developed by the motor during the period of acceleration from rest to the speed at which breakdown torque occurs. For motors that do not have a definite breakdown torque, the pull-up torque is the minimum torque developed up to rated speed.

Breakdown Torque—in an induction motor this is the maximum torque developed under rated voltage applied at rated frequency, with an abrupt drop in speed.

Pull-out Torque—with a synchronous motor is the maximum sustained torque that the motor will develop at synchronous speed for one minute, with rated voltage applied at rated frequency and with normal excitation.

Pull-in Torque—for a synchronous motor, this is the maximum constant torque under which the motor will pull its connected inertia load into synchronism, at rated voltage and frequency, when its field excitation is applied.

The speed to which a motor will bring its load depends on the power required to drive it; and whether the motor can pull the load into step from this speed depends on the inertia of the revolving parts. Thus, the pull-in torque cannot be determined without having the flywheel effect, WK^2, as well as the torque of the load.

Torque of d-c motors—is a direct function of the armature current and the field strength. With rated armature current and full field strength the torque produced will be approximately 100 percent of rated torque at any speed up to base speed.

Classifying Drives By Type

Machines can be classified according to starting load conditions:

1. Machines that can be readily arranged for starting partially unloaded —(a) Machines having uniform rotating motion and requiring medium values of static torque and constant pull-up torque. (b) Uniform rotating motion machines of the higher speeds, requiring relatively low static torque and where pull-up torque is an exponential function of the speed. (c) Reciprocating types of machines, such as air or gas compressors, where static torque requirements are usually high and pull-up torque varies with type of construction.

2. Machines that must be started unloaded—The material being processed completely obstructs motion after machine stops. To attempt to start a machine of this type under load requires prohibitive torques. Even if the torque were available, it might seriously injure or wreck the machine.

3. Machines that should be started unloaded—Any of the above types that contain an abnormal amount of inertia in flywheel effect. Such machines, if started without unloading, require considerable accelerating torque in addition to the load torque, thus causing excessive heating in the squirrel-cage rotor or in the starting winding in a synchronous motor. In addition, pulling high inertia loads into step with synchronous motors presents a difficult problem.

4. Machines which must be started fully loaded—(a) The inherent characteristics of the driven machine does not permit any practicable way of reducing the load. Usually, this will mean very high static and pull-up torques. (b) Operating conditions may permit temporary unloading but the motor must be good for the most extreme condition of starting. (c) Characteristics of the driven machine may be such that any deviation from starting under normal operating conditions will increase rather than decrease torque requirements.

A thorough analysis of the torque requirements in the starting and accelerating of any drive must include (1) loading conditions and (2) flywheel effect. There is no definite relationship between these two factors and both must be given individual consideration.

With the limited amount of static and pull-up torque available in most alternating current motors, it sometimes becomes necessary to modify operating conditions to satisfy torque limitations on the motor.

Two things can be done to relieve or minimize the starting torque demand. It is often possible to unload the driven machine before starting. Or, on large machines, the static friction of the assembly can be reduced by high pressure oil jacking on the bearings of the driven machine and/or the motor. Sometimes starting friction can be reduced sufficiently by the use of antifriction bearings.

If these methods of relieving starting duty are impractical, it becomes necessary to build the requisite starting torque into the motor. This effect usually can be accomplished by changes in the design of the motor, at

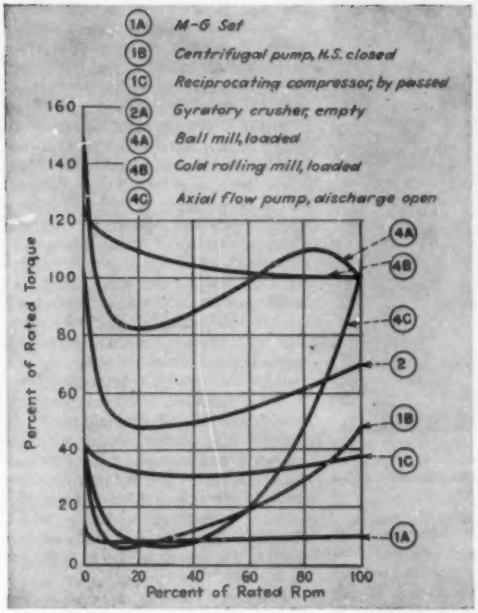

Fig. 1—Typical speed-torque curves of classes of drives. Acceleration time and flywheel effect are neglected in this chart.

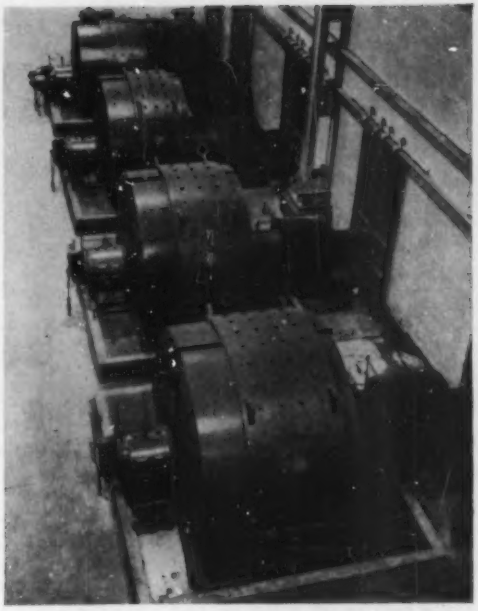

Fig. 2—These 4,000 hp d-c motors, applied to finishing stands in a strip mill, exemplify the type 4(a) load shown at the left.

a sacrifice of some other desirable motor characteristic.

As soon as the machine assembly begins to move, several things happen. The friction load decreases, usually very rapidly, and another element, that of the effect of inertia, enters the picture. The inertia effect, regardless of whether it is the linear or rotating acceleration of a mass, may be translated into effect on rotating acceleration at the motor shaft.

To relieve the pull-up and pull-in torque demand of the driven machine, it is generally accepted practice to "unload" machines of the larger sizes wherever feasible.

For example, with a reciprocating compressor, usual practice is to close the discharge valve and divert the discharge through a by-pass, which shunts out the back pressure from the receiving line by minimizing the torque required to turn over the unit. When operating speed has been reached, the lubrication of the sliding and rotating parts has become effective, decreasing the amount of torque required to overcome friction. The discharge valve then may be opened, the by-pass closed, and the machine will function in its normal manner.

Other types of devices may be unloaded by different methods. A centrifugal device may be partially unloaded by shutting off the intake or discharge of the unit. Machines such as heavy rolling mills or crushers are unloaded by running out the steel or the charge in the machine before shutting the unit down.

Reference Book Sheets, p 153, 155, classify machines by starting and accelerating characteristics, and Fig. 1 shows typical speed-torque curves. Some machines fall into more than one category because of features inherent in the type of unit under consideration. For instance, centrifugal blowers are included in both group 1(b) and in group 3(a). Here, although the load curve is the same in both cases, the construction of the machines in group 3(a) is such that the motor is called upon to accelerate a large amount of flywheel effect.

Examples of Drive Types

1(a). Motor-generator sets fall in this classification. Obviously a motor-generator set cannot conveniently be started under load, and therefore starting such a machine is easily accomplished.

On any machine with sleeve bearings, the shaft journals settle down on the bearing at standstill, practically eliminating the oil film between the journal and the bearing, which normally allows free rotation. Therefore, the static torque required to break the rotating mass free from rest is determined by various items, such as the weight of the rotating parts, the size, number and type of bearings, the length of time the machine has been at standstill, and the temperature and viscosity of the oil in the bearing. Besides the bearing friction at standstill, there may be additional items contributing to the total friction at rest. The most common of these, in the case of an m-g set is the friction of the brushes, particularly on the d-c machine.

As soon as the rotating parts begin to turn, the static friction effect practically disappears and is replaced by sliding friction of a much lower value. When lubrication becomes effective with rotation, the friction is further decreased.

Three values of static torque required to start m-g sets are given. The minimum is for standard small sets. Larger units such as are normally used in rolling mill and hoist service are good for 25 percent overload for two hours. Because of their relatively heavier construction of the rotating parts, they require slightly greater

Table I—Torque Available for Acceleration with Various Classes of Load

Torques	Class of load characteristic		
	(1) (Load Torque varies with rpm²) Percent	(2) (Load Torque varies with rpm) Percent	(3) (Load Torque constant) Percent
(a) Unloaded—Load torque at full speed = 60%			
Average motor torques	100	100	100
Average load torque	20	30	60
Available for acceleration	80	70	40
(b) Without Unloading—Load torque at full speed = 100%			
Average motor torques	100	100	100
Average load torque	33	50	100
Available for acceleration	66	50	0

Note: When the torque varies directly with the speed, the average torque is 1/2 of the maximum torque value at full speed.

starting torque. Sets such as those used for electrolytic tinning processes require higher starting torques than either of the others because they are usually built for low voltage and high current, and therefore have an abnormally large commutator and a great number of brushes.

After the unit has been broken loose from rest, it remains only to accelerate its mass to operating speed. As the set comes up in speed, the effect of windage becomes greater, although this item in a m-g set is almost negligible. The driving motor then is called upon to deliver torque not only to overcome friction and windage, but an additional quantity sufficient to bring the set up to speed in a reasonable length of time. Normally on a motor-generator set, the Wk^2 value is relatively small, so the driving motor has little difficulty in starting and accelerating the set to speed.

1(b). As a typical example of the machines covered in this group, consider the starting of a centrifugal pump. Note that on p. 153 and 155 the values of starting torque required are given as 40 percent, regardless of the loaded or unloaded condition of the pump. In a centrifugal device, the loading does not become effective until the machine is well up in speed. Because of this, the torque requirement of the device at starting varies little whether the machine is loaded or unloaded.

The pull-up and pull-in torques, however, are greatly affected by loading. When the pump is loaded, as it approaches full speed nearly full load torque is required to accommodate the load. In addition, the motor must still accelerate the Wk^2 to the ultimate operating speed. With a pump of this type, the fact that the inertia is not abnormally high is a favorable feature, since the unit can be pulled into step with a minimum of effort on the part of the motor.

1(c). Starting and accelerating characteristics in this group are typical of positive displacement reciprocating pumps or compressors, starting under full head back pressure. Such a machine will require full torque to force its liquid or gas into the receiving line against full pressure. After prolonged shut-downs, the bearings, cylinder walls and cross-head slide may be practically devoid of lubricant, and therefore, the static friction in the unit is much higher than it is with normal speed lubrication. These conditions result in a high torque demand at starting, as shown. To relieve this high torque demand, the compressor is usually unloaded by by-passing.

2(a). Machines coming under this classification, by the nature of the functions they perform, cannot readily be started under loaded conditions. Successful operation of a gyratory crusher, for example, depends on the constant agitation of its charge in the wedge-shaped space between the mantle and the liners. If this agitation ceases, as it would if the crusher came to a stop, the stone or ore settles down in the crushing chamber. By this jamming action the load prevents motion in either direction, unless torques far in excess of those for which the parts were designed are applied.

In normal operation, the charge in any type of crusher is run out before the machine is shut down. In emergency shutdowns, it is usually necessary to clean out the crushing chamber manually before attempting to start the unit.

3(a). There are many drives in industry which have load characteristics similar to those in the other types listed here, but where the flywheel effect is so great that it presents a special problem of accelerating the drive up to speed. For example, a large high speed axial compressor has the same starting and accelerating load conditions as any similar centrifugal device, but because of its construction, the Wk^2 is so high that special accelerating means often must be provided. This problem is treated later.

4(a). Machines of this type represent drives that offer no alternative to starting fully loaded. A large ball or rod mill, for example, cannot be unloaded without great difficulty. Fortunately, most such loads do not present the high flywheel-effect problem, although there are exceptions to that too, as for example, in a mill line shaft drive.

From the torque standpoint, the wound rotor induction motor would be the logical choice for these drives, but with the low speeds often involved, the power factor may be objectionably low, so synchronous motors are ordinarily used.

4(b). In this type are machines which might, under certain conditions, permit the use of lower pull-in torques than are indicated for the worst conditions. For example, with rubber-mill mixing rolls the batch could be run out before a synchronous motor pulls into synchronism. However, if a power failure occurs during the mixing cycle, the motor must be capable of starting and pulling in under full-load conditions, or the material being processed would be spoiled. Here, though it might be possible to take advantage of alleviating conditions, it becomes impracticable because of the serious loss represented in the value of the material spoiled.

4(c). The most common example is the axial flow pump usually used for low head high volume applications. Throttling of either the intake or discharge results in a higher torque demand.

Flywheel Effect

Relatively high values of Wk^2 flywheel effect present a starting problem, particularly with a-c motors.

Consider a fan drive where the average of the locked-rotor and pull-up torques of the motor is 100 percent, and the load torque varies as the

square of the speed from zero to full speed, (i.e., hp = rpm^2). Also assume that the driven machine can be unloaded during the starting period so that the load torque at full speed is 60 percent. The average load torque, neglecting breakaway torque, is then 60 percent $\times$ 1/3 = 20 percent. This equation is derived from the fact that the average torque value is 1/3 of the maximum torque value when the torque varies as the square of the speed. Similarly, taking other load-torque characteristics, as well as conditions of starting without unloading, obtain the results in Table I.

The example in Table I should serve to illustrate forcefully the importance of taking the flywheel effect into account; particularly with squirrel-cage induction motors and synchronous motors. In motors of this kind, the torques available for acceleration must be sufficient to bring the Wk^2 up to rated speed within a period of time which will preclude excessive heating of the squirrel-cage or amortisseur winding.

Standard squirrel-cage motors in generally accepted practice have an accelerating period of 15 sec or less. Cage motors can be designed for longer accelerating periods, but these require special consideration. With a standard cage motor the amount of flywheel effect, in lb-ft^2, which the motor can accelerate without excessive cage-winding heating, may be approximated by the equation:

$$Wk^2 = \frac{24.2 \text{ hp}}{(\text{rpm}/1{,}000)^2} \times \left(\frac{T_m - T_l}{100\%}\right) \quad (2)$$

where T_m is the percent average locked-rotor and pull-up torques of the motor T_l is the percent average load-torque and hp is the horsepower.

For illustration, refer to Table I and assume a motor rated 500 hp at 700 rpm (720 rpm synchronous), with T_m = 100 percent. With the aid of the above equation it will be found that Wk^2 values that can be accelerated are of the following order: In 1(a), 19,755; in 2((a), 17,286; and in 3(a), 9,878.

Conversely, if the exact load Wk^2 and percent average load torques are known, the equation may readily be transposed to determine the percentage average locked-rotor and pull-up torques required from the motor.

$$T_m = \frac{Wk^2 \times \text{rpm}^2 \times 100}{\text{Motor hp} \times 1{,}000^2 \times 24.2} + T_l \quad (3)$$

In 1(a) in Table I, it was found that a Wk^2 of 19,755 could be accelerated with 100 percent average motor torques. But if in 3(b) it is attempted to accelerate the same value

Fig. 3—Centrifugal fans drives like this 1,000 hp, 1,200 rpm cage motor can be partially unloaded by controlling dampers in the system. (Load type 3a).

of Wk^2, the required average motor torques,

$$T_m = \frac{19{,}755 \times 700 \times 700 \times 100}{500 \times 1{,}000 \times 1{,}000 \times 24.2} + 100 = 180\%$$

Certain kinds of driven machines have flywheels built into them for the express purpose of supplying stored energy to remove the peaks from intermittently repeated or widely fluctuating loads. Typical of these are punch presses and shears, which have such a wide application that a special high locked-rotor torque, high-slip cage motor has been standardized especially for the purpose. When motors are desired for a specific duty, the problem of starting time is taken care of in the design.

Where wound-rotor induction or direct-current motors are used on high-inertia drives, the time of acceleration is not critical from the standpoint of the motor. For wound rotor motors, the secondary resistance is designed for the service and duty cycle required. For direct current motors the control is designed to limit armature current to a value within the commutating and heating capabilities of the particular rating.

Flywheel Problems with Synchronous Motors

Synchronous motors have another definite limitation in applications involving high-inertia loads, namely the pull-in torque. A synchronous motor might be capable of starting and accelerating a load with a given flywheel effect, but may be unable to pull that load into synchronism. The problem of pull-in torques requires a lengthy discussion. (See "The Application of Synchronous Motors to High Inertia Loads", F. K. Brainard, *Allis-Chalmers Electrical Review*, Vol. IV, No. 3, September 1939.)

The equation given for inertia acceleration with squirrel-cage motors may also be used in a modified form for synchronous motors. But it is of little value unless the effect of inertia on pull-in torque is taken into account.

"Normal Load Wk^2" values for synchronous motors have been established and listed in NEMA Motor & Generator Standards, Rule MG10-39, based on the empirical equation:

$$\text{Normal Load } Wk^2 = \frac{3.75 \times 10^5 \times \text{hp}^{1.15}}{\text{rpm}^2}$$

Tables p 153 and 155, listing typical torque requirements, also give values of maximum ratio of actual to normal load Wk^2 as they are usually encountered, for each type.

It will be obvious that machines, particularly those listed under Type 3(a), must receive special consideration because of the high ratio of load-flywheel effect, especially when synchronous motors are to be used. In addition to the effect on pull-in torque, such extreme cases as bandsaw mills must have pull-up torques greatly in excess of the actual unloaded torque requirements to achieve a reasonable accelerating time.

Standard motor specifications take care of a reasonable range of torque requirement variations in the general purpose range of ratings.

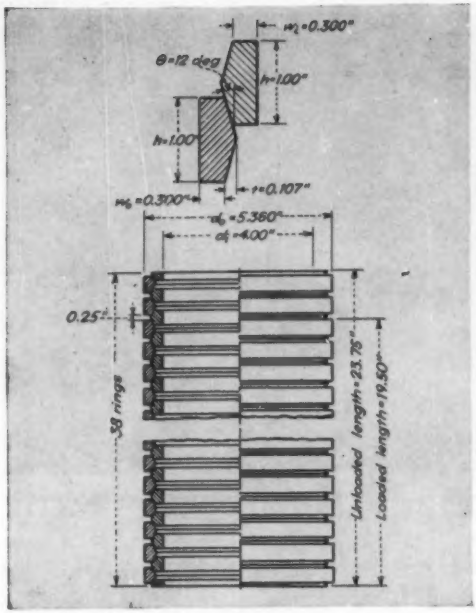

Fig. 1—Typical ring spring and an enlarged cross-sectional view showing a pair of typical inner and outer rings mating together.

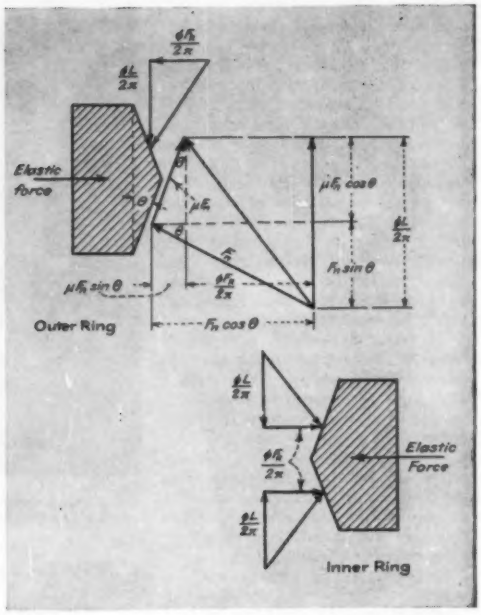

Fig. 2—Free body diagrams of the inner and outer ring sectors. The included angles of both these sectors is equal to ϕ radians.

Characteristics of Ring Springs

Ring springs are shock absorbers with low space requirements in proportion to their capacity because of high frictional forces.

TYLER G. HICKS

THE PRINCIPAL MERITS OF RING SPRINGS come from the high frictional forces developed therein. Among these merits are a high load capacity for their size and weight and the absorption of shock with low recoil.

A typical ring spring is sketched in Fig. 1. Axial loading of the spring causes the inner and outer rings to act as inclined planes. This forces an expansion of the outer rings and a contraction of the inner rings as the axial length is reduced.

Principles of Operation

The operating characteristics of the spring can be calculated from the dimensions and physical properties of the rings. Formulation of this calculation requires analysis of the wedging action of the springs and the stresses and the deflections of both the rings.

The wedging action of the spring is shown in Fig. 2. Here sectors of both the inner ring and the outer ring are shown as free bodies. These sectors both have an included angle of ϕ radians. Since the force L is uniformly distributed throughout the circumference of the ring, the axial force per radian is $L/2\pi$ and the axial force on each sector is $\phi L/\pi$, as shown in Fig. 2.

The resultant force acting on the wedging surface of each sector can be divided into two components—one normal to the surface and one tangential. The tangential component is due to friction and is equal to the normal component F_N times the coefficient of friction μ.

Fig. 2 shows these components acting on the lower wedge of the outer ring. The normal force F_N has the axial component $F_N \sin\theta$ and the radial component $F_N \cos\theta$. The tangential force F_N has the axial component $\mu F_N \cos\theta$ and the radial component $-F_N \sin\theta$. The axial and radial components of the resultant force are then obtained by addition as

$$\frac{\phi L}{2} = F_N \sin\theta + \mu F_N \cos\theta$$

$$\frac{\phi F_R}{2} = F_N \cos\theta - \mu F_N \sin\theta$$

Eliminating F_N from these equations gives

$$L = F_R \left(\frac{\sin\theta + \mu \cos\theta}{\cos\theta - \mu \sin\theta} \right)$$

Let

$$K_e = \frac{\sin\theta + \mu \cos\theta}{\cos\theta - \mu \sin\theta} \qquad (1)$$

Then

$$F_R = L/K_e \qquad (2)$$

Values of K_e are plotted in Fig. 3. When the spring is unloaded, the direction of the frictional forces are reversed. This has the effect of changing the signs of the terms involving μ in Eq (1). Thus, if

$$K_F = \frac{\sin\theta - \mu \cos\theta}{\cos\theta + \mu \sin\theta} \qquad (3)$$

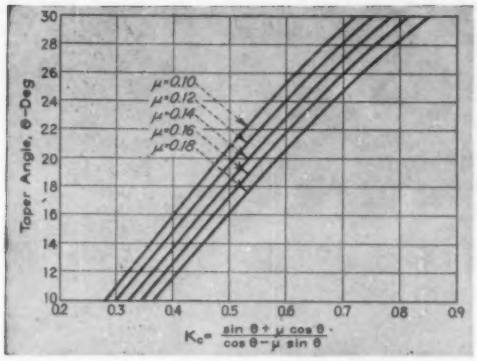

Fig. 3—Ring spring compression constant in terms of taper angle for various values of coefficient of friction.

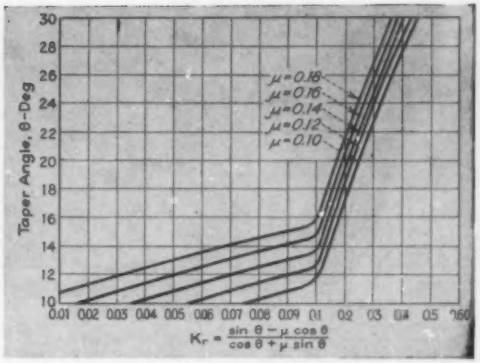

Fig. 4—Ring spring recoil constant in terms of taper angle for various values of coefficient of friction.

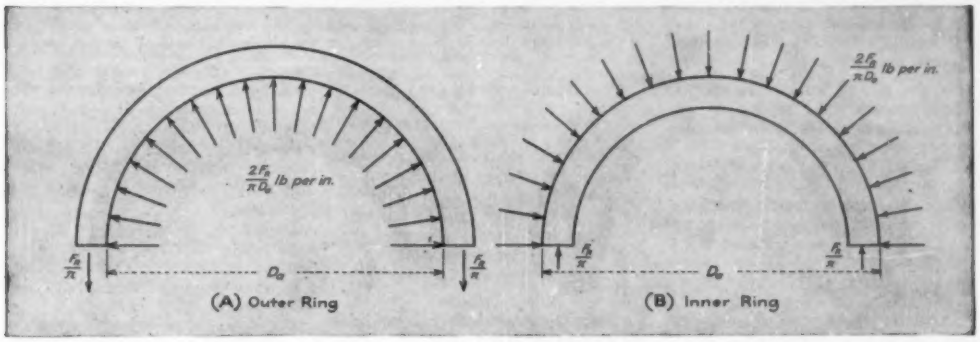

Fig. 5—Free body diagrams of inner and outer ring semicircles showing tangential elastic forces and radial component of pressure.

Then, during recoil of the spring

$$F_R = L'/K_r \qquad (4)$$

Values of K_r are plotted in Fig. 4. The axial load during recoil is less than that during loading. However, F_R is the same in both loading and unloading.

For calculation of the stresses and deflection, it is necessary to determine the total wedging forces acting in the spring. From Fig. 1, it can be seen that all except the end rings have two wedging surfaces. Therefore, the radial force $\phi F_R/2\pi$ is applied twice to each ring sector with included angle ϕ. The total radial force is then equal to $\phi F_R/\pi$.

This force can be considered as uniformly distributed about the mean circumference of the wedging surfaces. The diameter D_a of this mean circumference is

$$D_a = \frac{(d_o - 2w_o) + (d_i + 2w_i)}{2} \qquad (5)$$

where d_o, w_o, d_i and w_i are defined in Fig. 1. The length of this circumference included in a sector with included angle ϕ is $\phi D_a/2$. Thus, the force per unit length of circumference is the force applied to the sector divided by the circumference included in the sector or,

$$\frac{\phi F_R/\pi}{\phi D_a/2} = \frac{2F_R}{\pi D_a}$$

Halves of both the inner ring and the outer ring are shown as free bodies in Fig. 5. The resultant force exerted on the circumference by the distributed force is opposed by two tangential forces at both ends of the diameter. The resultant force is equal to the projected length D_a of the semicircle circumference times the force per unit length or $2F_R/\pi$. Each of the tangential forces is therefore F_R/π. For the inner ring, the force is compressive; for the outer ring, it is tensile.

These forces are related to the tangential stresses in the rings. Let S_i and S_o be the stresses in the inner and outer rings respectively. Then the areas A_i and A_o of the inner and outer rings are given by the formulas:

$$A_i = \frac{F_R}{\pi S_i} = \frac{L}{\pi K_r S_i} \qquad (6)$$

$$A_o = \frac{F_R}{\pi S_o} = \frac{L}{\pi K_r S_o} \qquad (7)$$

The axial deflection of the spring is based on the change in radius of the inner and outer rings. The change in circumference under deflection is $S\pi D_a/E$, where S is the tangential (tensile or compressive) stress in the (outer or inner) ring. The change in radius is then $SD_a/2E$. The outer ring will accordingly have an increase in radius by the amount $S_oD_a/2E$, and the inner ring will have a decrease in radius by the amount $S_iD_a/2E$. Therefore, if two points of the inner and outer ring are originally touching, after deformation they will have a radial distance of $D_a\ (S_i + S_o)/2E$ between them.

The effect of this radial deformation on the axial deflection of the spring is shown in Fig. 6. The axial movement of the rings is sufficient to

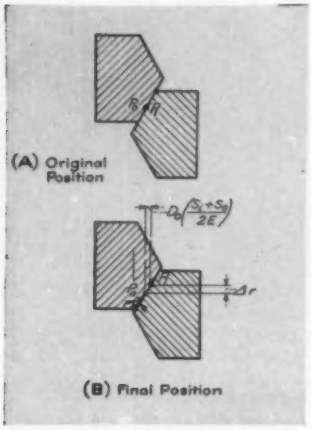

Fig. 6—Relationship between the radial and axial relative motion of the rings.

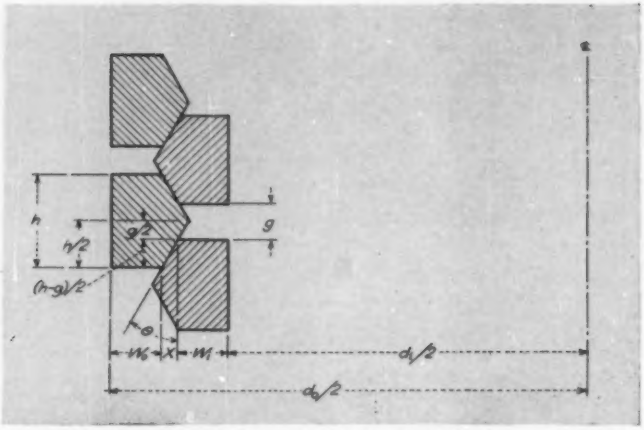

Fig. 7—Cross-section of mating rings showing, the relationships between dimensions of the rings and their positions relative to the longitudinal axis of the ring spring.

keep the mating surfaces in contact. Therefore, the axial motion Δr per wedge surface is given by the formula:

$$\Delta r = D_a \left(\frac{S_i + S_o}{2E} \right) \cot \theta$$

When the average stress S_a is defined as

$$S_a = \frac{S_i + S_o}{2} \tag{8}$$

this formula becomes

$$\Delta r = D_a S_a / E \tan \theta \tag{9}$$

When there are n rings in the spring (counting each end ring as half a ring), the total deformation Δt of the entire spring is

$$\Delta t = n \, \Delta r$$

or

$$\Delta t = n D_a S_a / E \tan \theta \tag{10}$$

The cross-sectional areas of the rings can be calculated from the dimensions defined in Fig. 1 by the simple formula:

$$A_o = h \left(w_o + \frac{t}{2} \right) = h w_o + \frac{h^2 \tan \theta}{4} \tag{11}$$

$$A_i = h \left(w_i + \frac{t}{2} \right) = h w_i + \frac{h^2 \tan \theta}{4} \tag{12}$$

The relationship between the inside diameter and the outside diameter can be determined from Fig. 7. The equation expressing this relationship is

$$\frac{d_o}{2} = \frac{d_i}{2} + w_i + X + w_o \tag{13}$$

The quantity X can be determined from the ring height h, the axial gap between rings g and the ring taper angle θ. As can be seen from Fig. 7, the formula for X is

$$X = \frac{h - g}{2} \tan \theta$$

Combining this with Eq (11) gives

$$d_o = d_i + 2w_i + 2w_o + (h - g) \tan \theta \tag{14}$$

The work required to load the spring is the average axial force during loading times the total deformation Δt. The average axial load is half the initial load (zero) plus half the final load L. Hence the work is

$$W_o = L \, \Delta \, t/2 \tag{15}$$

Similarly, the work released in unloading the spring is

$$W_R = L' \, \Delta \, t/2 \tag{16}$$

Hence, the energy dissipated by loading and unloading the spring is

$$W_o = (L - L') \, \Delta \, t/2 \tag{17}$$

Ring Spring Design Practice

Recommended approximate proportions are:

1. Compressed height should be at least four times deflection.
2. Ring height should be 15 to 20 percent of outside diameter.
3. Outside diameter and height are usually as large as space requirements permit.
4. Thin ring sections are preferred to thick ones.
5. Ring taper should be 1 to 4.

The proportions given above are only approximate. Frequently specially designed springs will deviate from the above rule-of-thumb proportions.

The coefficient of friction is estimated as from 0.10 to 0.18.

In current practice, allowable stresses of 160,000 psi for steel not machined after heat treatment and 200,000 psi for machined steel are used. For a vibratory load these would be reduced substantially. However, because of these high allowable stresses, it is standard practice to make thorough tests of the spring under load before approving the design for production.

Load capacities of ring springs are usually between 2 and 100 tons. Deflections are usually between 1 in. and 1 ft. Photographs of ring springs are shown in Fig. 8.

The formulas developed above can be applied to the design of a spring subject to the following specifications:

(a) The material has an allowable stress of 175,000 psi and a modulus of elasticity of 29,000,000 psi. The coefficient of friction between wedging surfaces is 0.12.

(b) The inside diameter is 7 in., and the outside diameter must not exceed 9 in. The taper angle θ is 14 deg. The ring height h is 15 percent of the allowable outside diameter or 1.35 in. The axial gap between rings is 25 percent of the ring height.

(c) The axial load is 56 tons and the axial deflection should be about 8 inches.

The first step is the calculation of the dimensions of the inner ring which would give a stress of 175,000 psi at the full axial load. On the basis of the above formulas, it was calculated that $A_i = 0.537$ sq. in. and $w_i = 0.314$ inches.

The next step is the fixing of the dimensions of the outer ring. This is carried out by a trial and error process. An area is estimated for the cross-section of the outer ring. Calculations

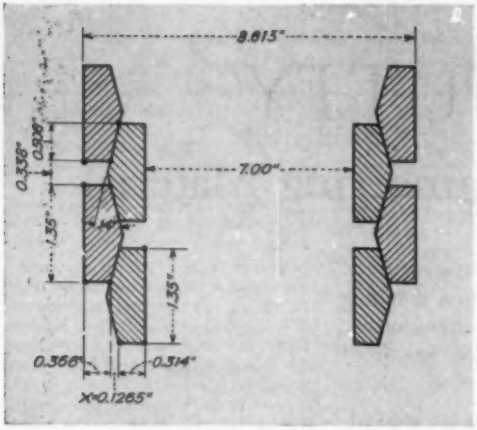

Fig. 8—Cross-sections of ring spring showing calculated dimensions of rings for a particular ring spring under consideration.

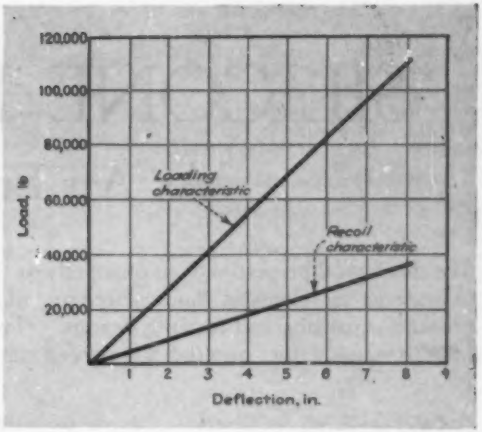

Fig. 9—Results of a calculation of the loading and unloading load-deflection characteristics of the ring spring of Fig. 8.

are then made to determine whether or not the outside diameter and stress meet the specifications. Calculations show that when $A_o = 0.609$ sq. in.; then $S_o = 154{,}400$ psi, $w_o = 0.366$ in., and $d_o = 8.613$ in. Therefore, this value of the area is satisfactory.

With S_o and S_i now known, the next step is to calculate the number of rings. The axial deflection per ring Δr is 0.176 in. From this the number of rings required is seen to be 46.

The dimension of this spring are shown in Fig. 9. The energy dissipated in loading and unloading the spring under full load is calculated as 303,000 lb. in. The recoil force is calculated as 37,200 lb. The loading and unloading load-deflection characteristics are shown in Fig. 10.

The formulas developed above can also be applied to an investigation of an existing spring. The spring shown in Fig. 1 is made of a material with allowable stress 150,000 psi and modulus of elasticity 29,000,000 psi. The coefficient of friction is 0.10.

The results of an analysis of this spring are as follows:

On loading, the axial load is 53,200 lbs. The recoil axial load is 18,300 lbs. The axial deflection per spring is 0.114 in., and the total axial deflection is 4.33 inches.

Applications

Several possible applications of ring springs are shown in Figure 11. As can be seen, these are in a large variety of fields.

Pipe hangers, for heavy lines subject to severe vibration require springs of high capacity and light weight. Ring springs for vertical support and lateral bracing would damp vibrations because recoil forces are low. The recoil force can be made as low as 25 percent of the loading force. Extra safety comes from the fact that the spring can continue to function even though several rings are broken.

Support of vibrating machinery, could be accomplished through ring springs. Where loads are exceptionally large, two ring springs could be used at each corner, one inside the other.

Absorption of shock loads such as those encountered in plows, trench diggers, and excavating machinery are important applications. Shock loads which would destroy usual wire coil springs would have little effect on properly designed ring springs. Application studies would have to consider the type of recoil desired.

Small ring springs could be used for light shock loads where low recoil forces are required. A case where this type of loading occurs is the conventional tractor seat. However, small capacity ring springs have not yet been applied in practice. The lowest capacity used to date is about two tons.

Landing gears for light and medium-weight airplanes, elevator shock absorbers, supports for steam condensers, heavy vehicles, mechanical power transmission devices, supports for vertical shafts, and vibration damping devices are other possible applications of ring springs.

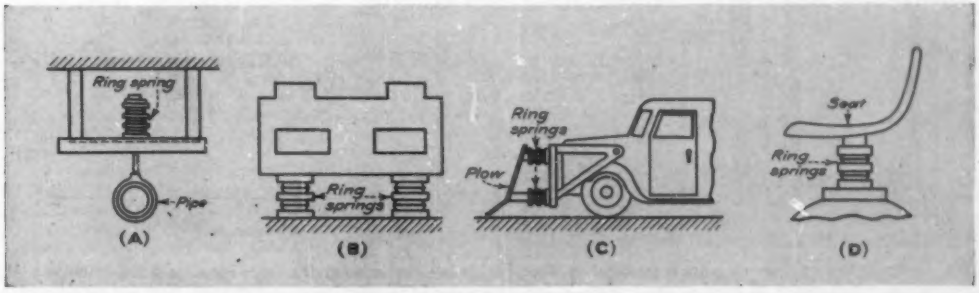

Fig. 10—Possible applications. (A) pipe hangers. (B) vibrating machinery supports. (C) plow supports. (D) tractor seat springs.

SILICONE PUTTY

As An Engineering Material

The rheological properties of silicone putty or "bouncing putty" indicate its usefulness in shock absorbing, vibration damping, pressure equalizing and leveling devices. Flow characteristics of this semi-plastic material have been studied in detail.

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FUNCTION OF FLUIDS and soft plastic solids in physical dampers, shock absorbers, leveling mechanisms and similar devices depends largely on their consistency, that is, flow vs force relationship. Hydraulic shock absorbers, such as used in automobile wheels, airplane landing gear struts, recoil mechanisms on large caliber guns, and on the controls of naval gun directors are designed to absorb and dissipate undesirable kinetic energy. Other shock absorbing devices, such as those using springs or compressed air, store kinetic energy but do not dissipate it. (See "Hydraulic Shock Absorber Orifice Designs and Equations," Joseph Brown, PRODUCT ENGINEERING, page 92, February 1948.)

For some damping applications, a rather stiff or viscid material is more suitable than a conventional hydraulic fluid. Clearances in the flow chamber need not be kept within such close tolerances, and the flow chamber itself can be small and of rather simple design.

Silicone putty, or "bouncing putty" has been suggested as a suitable material, thus determination of its flow properties was essential. Bouncing putty is related chemically to silicone rubber, but displays some unusual properties. It can be stretched or pulled out of shape without any tendency to return to its original dimensions. When rolled into a ball, it bounces faster and to a greater height than the average natural rubber ball. When pulled with a sudden force or struck a hard blow, it shatters into pieces. Yet left by itself, pieces of it will flow together and flatten out freely and evenly.

Thus, under moderate stress or when adequately confined, bouncing putty acts like a viscous liquid or a soft plastic solid; under great stress, not adequately confined, it will shatter like other solids.

Rheology

Rheology, the science of deformation of matter, is characterized by several types of flow, and by several properties possessing common names, but not too commonly known definitions. Some of these terms are mobility, stiffness, consistency, rigidity, strength, hardness, cohesion, toughness, tacki-

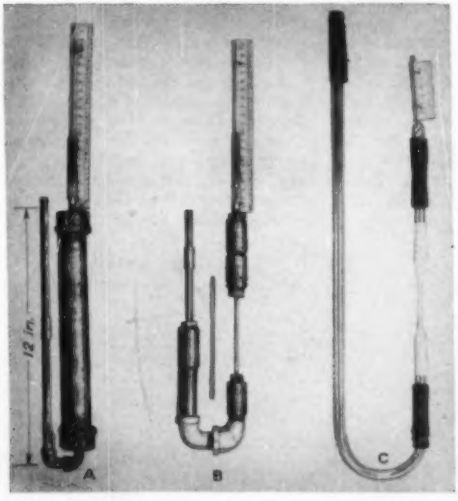


Fig. 1—Plastic flow of bouncing putty is measured in these viscometers, which consist of tubes of small diameter and relatively long length, to create linear flow.

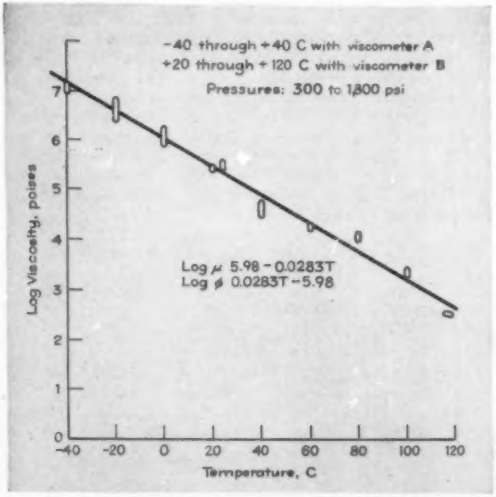


Fig. 2—Change in fluidity with temperature is shown in this plot of logarithm of viscosity against temperature. Since viscous flow was measured, effect of turbulent flow was removed by using tubes.

Table I—Viscosity and Fluidity at Controlled Temperatures and Pressures

Applied Pressure, psi	Rate cu mm/sec	Viscosity 10^5 poises	Fluidity, microrhes	Log Viscosity
		−40.0 C, Viscometer A		
1,500	0.269	120.0	0.085	7.08
		−20.0 C, Viscometer A		
1,500	1.39	22.2	0.450	6.35
1,200	1.03	23.8	0.420	6.38
900	0.612	30.0	0.333	6.48
600	0.184	66.5	0.150	6.82
		0.0 C, Viscometer A		
1,500	4.06	7.54	1.33	5.88
1,200	2.81	8.72	1.15	5.94
900	2.38	7.70	1.30	5.89
600	1.57	7.80	1.28	5.89
300	0.448	13.7	0.730	6.14
		20.0 C, Viscometer B		
1,800	0.625	1.80	5.55	5.26
1,500	0.492	1.90	5.26	5.28
1,200	0.369	2.04	4.90	5.31
900	0.268	2.10	4.76	5.32
600	0.168	2.24	4.46	5.35
300	0.075	2.51	3.98	5.40
		20.0 C, Viscometer A		
1,500	16.7	1.83	5.47	5.26
1,200	13.5	1.81	5.52	5.26
900	9.30	1.93	5.07	5.30
600	6.13	2.00	5.00	5.30
300	2.83	2.16	4.63	5.33
100	1.02	2.00	5.00	5.30
80	0.810	2.02	4.95	5.31
60	0.690	2.01	4.98	5.30
40	0.395	2.07	4.83	5.31
20	0.190	2.15	4.65	5.33
10	0.0903	2.26	4.42	5.35
		20.0 C, Viscometer C		
15.4	1.24	3.05	3.28	5.48
13.5	1.04	3.18	3.14	5.50
11.6	0.897	3.15	3.17	5.50
9.65	0.709	3.33	3.00	5.52
7.72	0.529	3.57	2.80	5.55
5.79	0.383	3.69	2.71	5.57
3.86	0.229	4.12	4.12	5.62
1.93	0.110	4.28	2.34	5.63
		40.0 C, Viscometer B		
1,800	3.58	0.307	32.6	4.49
		40.0 C, Viscometer A		
1,200	67.8	0.362	27.6	4.56
600	31.9	0.383	26.1	4.58
100	5.27	0.390	25.6	4.59
60	2.99	0.409	24.4	4.61
20	0.931	0.439	22.8	4.46
		40.0 C, Viscometer C		
15.4	5.98	0.631	15.8	4.80
11.6	4.19	0.675	14.8	4.83
5.79	2.01	0.704	14.2	4.85
1.93	0.661	0.714	14.0	4.85
		60.0 C, Viscometer B		
1,800	6.97	16.1	62.1	4.21
1,500	5.46	17.2	58.2	4.24
1,200	4.52	16.6	60.3	4.22
900	3.28	17.1	58.5	4.23
600	2.17	17.3	57.8	4.24
300	0.996	18.8	53.2	4.27
		80.0 C, Viscometer B		
1,800	10.3	10.9	91.7	4.04
1,500	8.00	11.7	85.5	4.07
1,200	6.40	11.7	85.5	4.07
900	4.74	12.0	83.6	4.08
600	2.90	12.9	77.6	4.11
300	1.34	14.1	71.2	4.15
		100 C, Viscometer B		
1,500	42.6	2.20	455.0	3.34
1,200	30.6	2.45	408.0	3.39
900	22.8	2.46	507.0	3.39
600	16.5	2.27	441.0	3.36
300	7.0	2.68*	373.0	3.43
		116 C, Viscometer B		
300	53.7	0.349	2,870.0	2.54
		118 C, Viscometer B		
300	57.0	0.329	3,040.0	2.52

ness, fluidity, plasticity, brittleness, ductility and malleability. The types of flow include turbulent flow, viscous flow, elastic deformation, plastic flow, and pseudo-plastic deformation or flow.

Fluids—gases or liquids—are characterized by fluidity and viscosity, reciprocal properties in which rate of flow is directly proportional to the shearing stress.

Plastics and solids have the reciprocal properties of mobility and stiffness, in which rate of flow is directly proportional to the shearing stress in excess of a yield value. Plasticity, which enables a material to be deformed without rupture at a rate not proportional to shearing stress, is a complex property made up of yield value and mobility. Pseudo-plastic flow represents a complex type of plasticity where the yield value is either not a definite value or non-existant, and it may represent a temporary modification of the internal physical structure of the material.

In measuring viscous or plastic flow, the effect of all other types of flow, primarily turbulent flow, must be removed. This is conveniently done by creating linear flow through tubes of small diameter and relatively long length; thus, the rate of flow of each molecule depends only on the tangential force between it and its neighbors.

Procedures and Calculations

Viscosity, as measured by efflux through a vertical tube of small diameter, is calculated as follows:

$$\mu = \frac{\pi G R^4 P T}{8 L V}$$

where

μ = viscosity in $\frac{8}{\text{sec} \times \text{cm}}$

π = 3.1416
P = pressure, g/sq cm
G = acceleration due to gravity, 980.3 cm/sec² in Pittsfield, Mass.
T = time in seconds
V = volume of flow in cu cm
R = radius of tube in cm
L = length of tube in cm

Converting pressure to cm of Hg or psi,

$$\mu = 5{,}216 \frac{R}{L} \cdot \frac{hT}{V}$$

where h is pressure in cm of Hg and

$$\mu = 27{,}068 \frac{R}{L} \cdot \frac{pT}{V}$$

where p is pressure in psi.

For any viscometer

$$\mu = \frac{CPT}{V}$$

where C is the instrument constant.

For this investigation, no kinetic energy correction was necessary. All viscosities were determined by absolute measurement, as no calibration reference material was available in this viscosity range.

The following tabulation indicates the scope and range of the investigation:

Viscometer	A	B	C
Radius, cm	0.184	0.0762	0.278
Length, cm	15.24	14.6	6.6
Temperature, C			
max.	40.0	118.0	40.0
min.	−40.0	30.0	20.0
Pressure, psi			
max.	1,800.0	1,800.0	15.4
min.	10.0	300.0	1.93

Temperatures were controlled on all data to within ±0.1 C. Pressures were read on gages in psi and cm of Hg, with an accuracy of about ±1 percent. Radius and length measurements were made with about the same accuracy. The overall accuracy should

be in the order of ±5 percent or better. These viscometers are shown in Fig. 1. Table I gives a summary of data at controlled temperatures and at regular pressure intervals.

Results

FLUIDITY VS TEMPERATURE. Fig. 2 shows the logarithm of viscosity in poises plotted against temperature in degrees centigrade. The points show extreme values measured at 300 to 1,800 psi pressures. The linear curve has the formula

$$\text{Log } \mu = 5.98 - 0.0283T$$
$$\text{or } \mu = 9.55 \times 10^{-0.0283T}$$

$$\text{and Log } \phi = 0.0283T - 5.98$$
$$\text{or } \phi = 1.047 \times 10^{-6} + 0.0283T$$

where ϕ = fluidity (reciprocal of viscosity, μ)
T = temperature.

A review of the literature reveals that no single equation expresses accurately a direct relationship between viscosity of liquids and temperature. E. W. Madge, *Journal of Physical Chemistry*, 34 1599, (1930), states that "a logarithmic formula, rather than one involving merely power terms, will have a greater theoretical significance." He relates viscosity to temperature as follows:

$$\mu = \frac{Ae^{BT}}{\tau - b}$$

where A and B = constants
T = absolute temperature
τ = relaxation time of shearing force, which is related to temperature
b = temperature of complete solidification.

Andrade, *Nature*, 125 309 (1930), Busse and Karrer, *Kolloid Z.*, 65 211 (1933), and others favor the formula

$$\mu = Ae^{B/T}$$

It is derived from the Maxwell viewpoint, that viscosity is a measure of the velocity with which the potential energy, stored in the material by the shear force under conditions of laminar flow, is transferred to heat.

However, with the data shown in Fig. 2, the logarithm of viscosity (or fluidity) is definitely more proportional to temperature than to its reciprocal.

RATE OF FLOW VS SHEARING STRESS. Fig. 3 shows rates of flow of bouncing putty in cu min per sec over three pressure ranges: (1) 1.93 to 15.4 psi, (2) 10.0 to 100.0 psi, and (3) 300.0 to 1,800.0 psi.

At the higher pressures the curves do not point toward the origin, indicating a possible yield value and that bouncing putty can be considered a soft plastic solid. However, at lower pressures there is a definite curvature towards the origin and any yield value practically disappears. Thus, bouncing putty can be considered a true liquid whose fluidity increases slightly with shearing stress.

FLUIDITY VS SHEARING STRESS. Fig. 4 shows the apparent fluidity of bouncing putty at 20 C, at pressures from 1.93 to 1,800 psi. Since the change in apparent fluidity is proportional to proportionate changes in pressure rather than to pressure itself, fluidity should be related to the logarithm of pressure. Fig. 5 shows the fluidity of bouncing putty in microrhes vs the logarithm of the applied shearing stress in psi, at various temperatures. The linear curves are formulated as follows:

at 20 C, $\phi = 1.134 \log P + 1.86$
40 C, $\phi = 6.4 \log P + 9.3$
60 C, $\phi = 11.4 \log P + 25.0$
80 C, $\phi = 25.0 \log P + 10.0$

Although plastic and viscous deformation are a function of time, elastic deformation is nearly instantaneous. No elastic deformation was observed either by excessive flow near zero time, nor by recovery when pressure was removed. Possibly a more intricate setup would detect this.

Bouncing putty is a non-Newtonian liquid, in which the rate of flow is not directly proportional to shearing stress. Markus Reiner, in *Physics*, 5 321 (1934) discusses "The Theory of Non-Newtonian Liquids" and writes, "It is not possible to decide by appearance whether a given material which flows is a liquid or a very soft plastic solid. Every flow investigation has therefore to be expressed at the first stage in terms of consistency which concept can be applied to liquids and solids as well.

"From an examination of the consistency curve it is sometimes possible to decide whether the material under

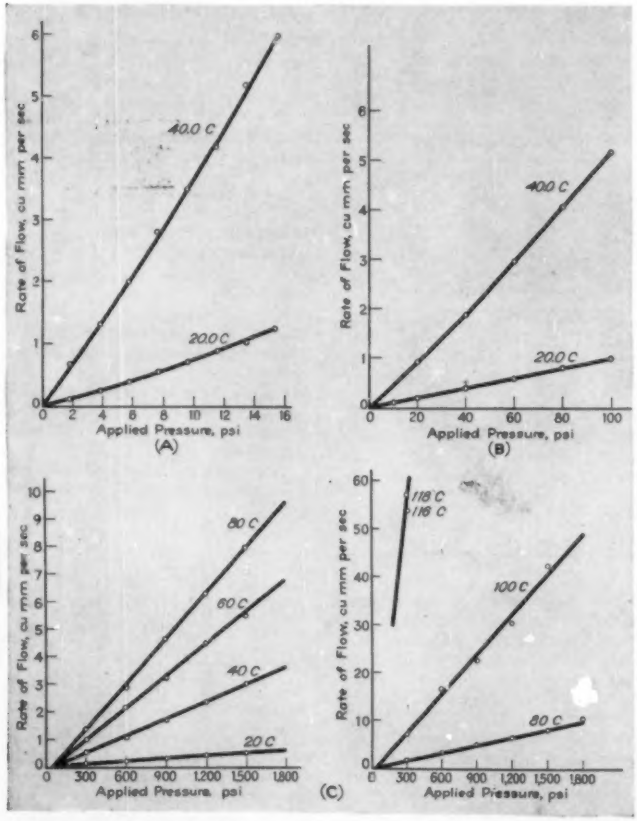


Fig. 3—Rate of flow vs shearing stress is shown over three pressure ranges: (A) 1.93 to 15.4 psi; (B) 10 to 100 psi; and (C) 300 to 1,800 psi.

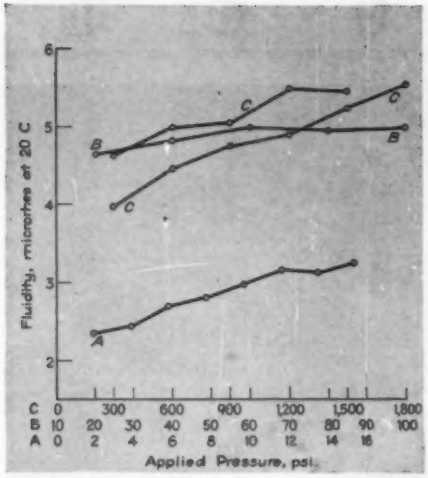


Fig. 4—Fluidity vs shearing stress is indicated in this graph of apparent fluidity from 1.93 to 1,800 psi. Change in apparent fluidity is proportional to pressure changes.

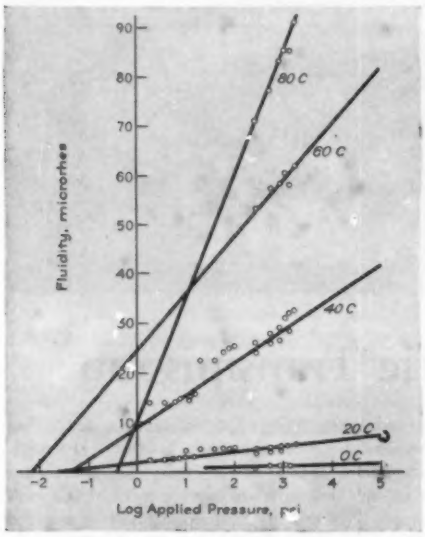


Fig. 5—Logarithmic plot of applied pressure vs fluidity gives straight lines, since apparent fluidity is proportional to logarithmic pressure changes rather than pressure itself.

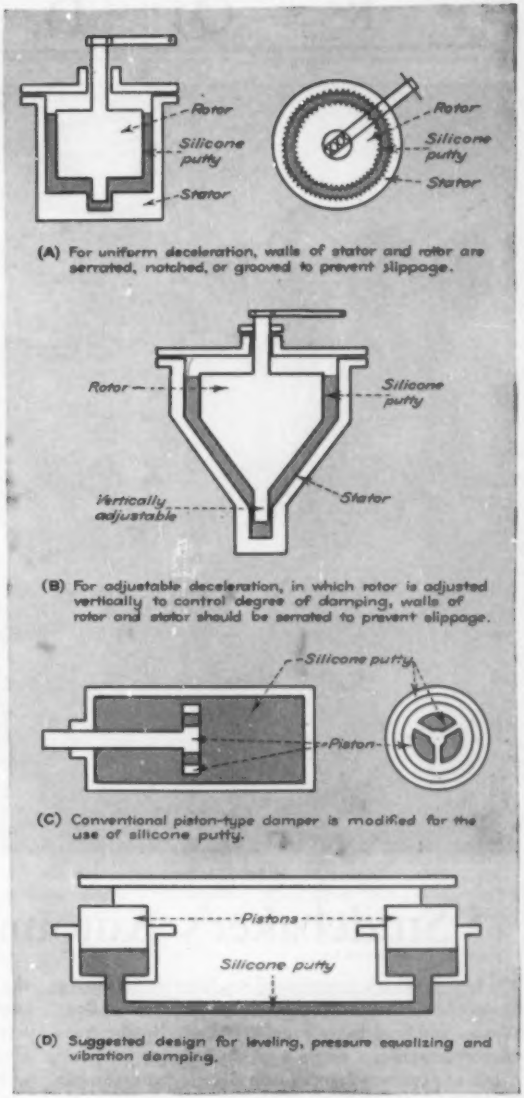
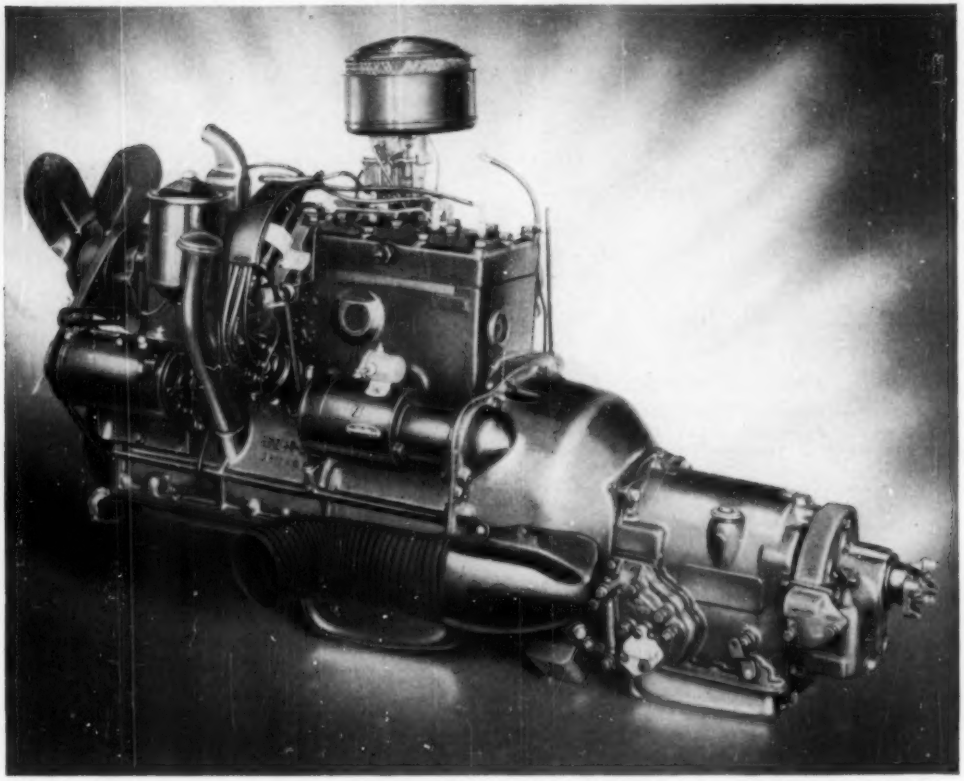

Rotor
Silicone putty
Stator
(A) For uniform deceleration, walls of stator and rotor are serrated, notched, or grooved to prevent slippage.
Vertically adjustable
(B) For adjustable deceleration, in which rotor is adjusted vertically to control degree of damping, walls of rotor and stator should be serrated to prevent slippage.
Piston
(C) Conventional piston-type damper is modified for the use of silicone putty.
Pistons
(D) Suggested design for leveling, pressure equalizing and vibration damping.

Fig. 6—Possible applications of bouncing putty: (A) For uniform deceleration; (B) for adjustable deceleration; (C) modified piston-type damper; and (D) pressure equalizing and vibration damping.

investigation is a solid. If the consistency curve starts at a point on the P-axis, other than the origin, the material is a solid. This statement cannot be reversed. If the consistency curve passes through the origin, the material may be either a liquid or a solid which does not adhere to the wall of the apparatus, i.e., which shows slippage or generally a wall-effect."

SUMMARY OF PROPERTIES

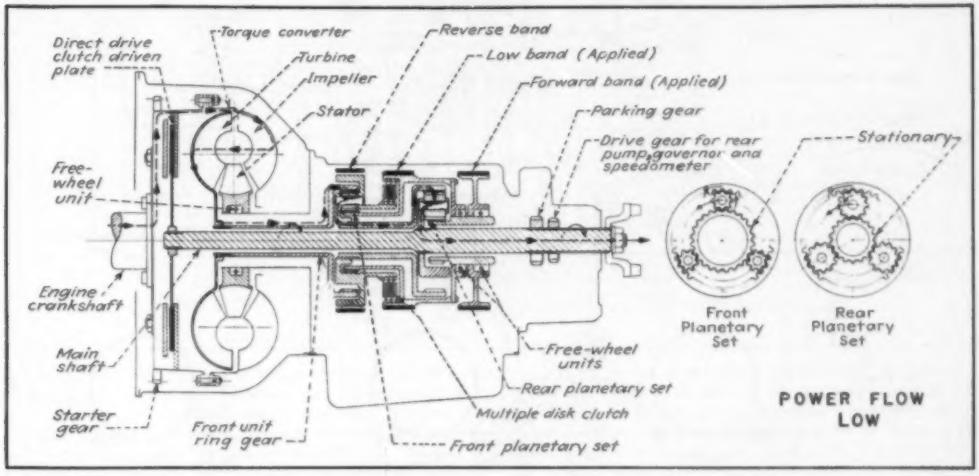
The viscosity and fluidity of bouncing putty at 20 C and 60 psi are approximately 260,000 poises and 3.8 microrhes respectively. Over the temperature range −40 to 120 C, its viscosity and fluidity vary with temperature as follows: Log μ = 5.98 − 0.0283T, and log ϕ = 0.0283T − 5.98. Over the pressure range 2 to 1,800 psi, its fluidity in microrhes depends on shearing stress as follows: ϕ = 1.134 log P + 1.86, at 20 C; and ϕ = 6.4 log P + 9.6 at 40 C. The density of bouncing putty was measured as follows: at 100 C, 1.06 g/cu cm; at 20 C, 1.12 g/cu cm; and at −40 C, 1.16 g/cu cm.

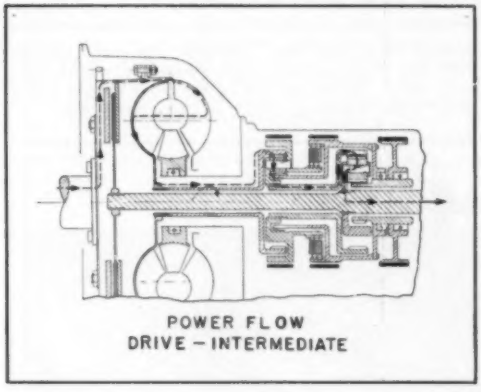


Studebaker's Automatic Transmission

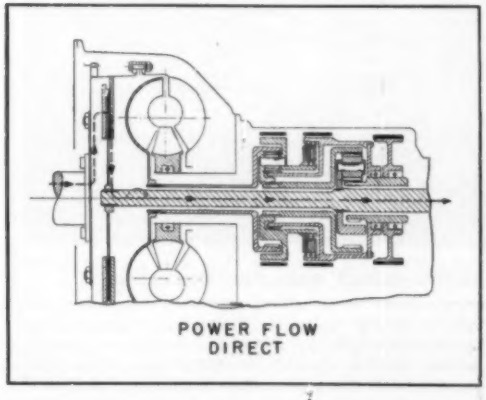
The new automatic transmission available on the current model of Studebaker cars is a joint development of Borg-Warner and Studebaker engineers. Basically, the transmission comprises a single stage fluid torque converter, a train of planetary gears and a hydraulic control system. Studebaker's design is somewhat simpler than other transmissions of this type. The converter elements are of stamped construction, rather than cast. Two simple planetary gear sets are used in place of a single compound planetary. Design for simplicity is evident also from the use of a mechanical governor, single acting servo units and completely unitized construction. A direct drive clutch is incorporated in the transmission. At some speed between 18 and 58 mph—depending on throttle position—this clutch is engaged automatically, connecting the engine directly to the rear axle. The new transmission has several features that are unique from the operational standpoint. One of these is a device that prevents car creep when the engine is idling. Hydraulic interlocks guard against driver error. The car cannot be thrown into reverse while moving forward at speeds over 5 mph. Nor can the mechanical brake be engaged unless the car is stopped. Two free-wheel units on the rear planetary set are employed in the operation of the gear train. Among other functions, these units act as a hill holding mechanism. When stopped on an upgrade with the selector lever in the "Drive" position and engine running, the car cannot roll backward even though brake pedal and accelerator are released.

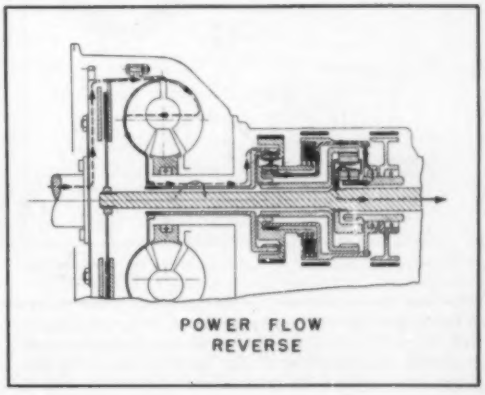
Because the direct drive clutch isolates the converter during most normal driving, power loses are minimized. Therefore, addition of the automatic transmission does not require an increase in engine horsepower. The standard 102 hp Studebaker engine is used.

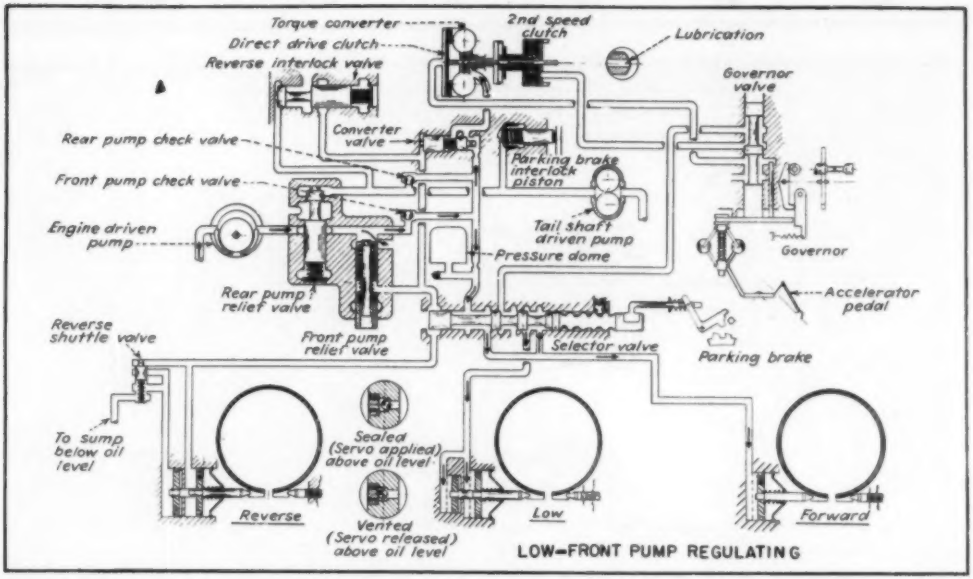




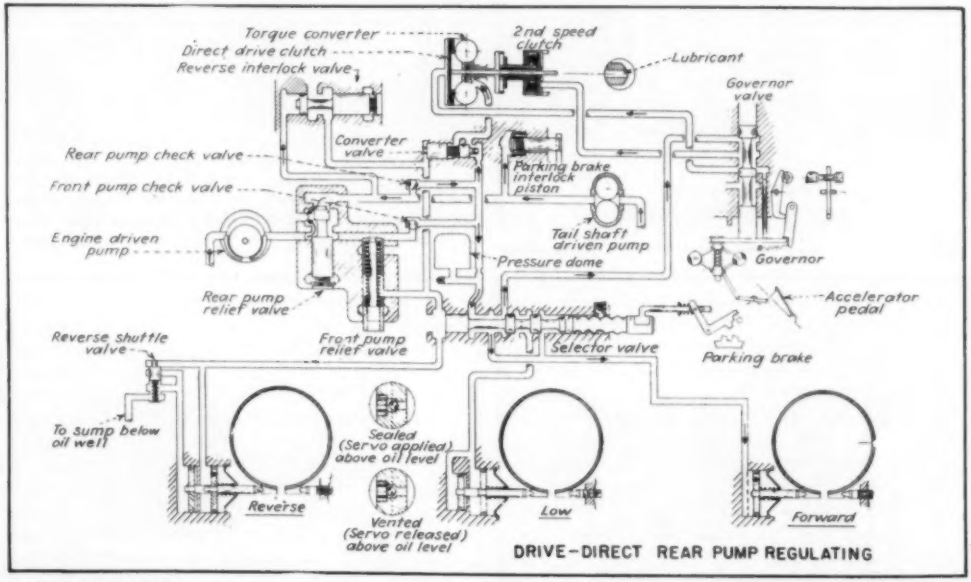
HYDRAULICALLY applied friction bands and clutches determine the path of power flow from engine to rear wheels. Broken lines in these schematic drawings show the paths for the 4 drive conditions. In low, engine torque is multiplied by action of the torque converter and the two planetary gear sets. This position is used only for unusually heavy starting requirements. All normal driving is done with the steering column selector lever in the "D" (Drive) position. When starting with this lever setting, power is delivered as shown in the sketch marked "Intermediate". The converter and rear planetary set provide all torque multiplication. When the car speed is sufficient, the direct drive clutch is automatically engaged. This clutch bypasses the converter and both planetary sets and completes a mechanical connection between engine and wheels. For reverse, power flows through the converter and both planetary sets. Reversal is accomplished in the front set by the action of the reverse band which locks the planet carrier. (*continued on next page*)



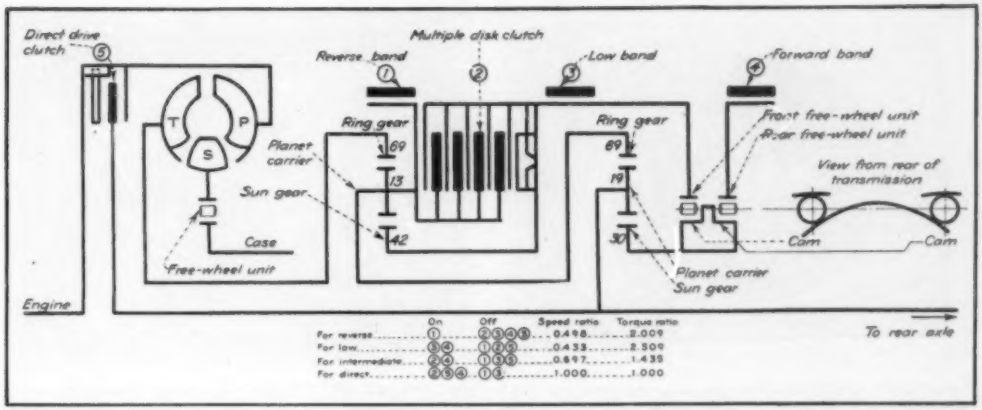




INTERLOCKS prevent engagement of parking brake or reverse band when car is in forward motion. Pressure from the rear pump actuates the parking brake interlock piston, which keeps the parking dog from contacting the teeth of the parking gear. Similarly, rear pump pressure shifts the reverse interlock valve, venting the reverse band apply servo. No pressure can be applied to reverse piston when the car is moving forward at speeds over 7 mph.

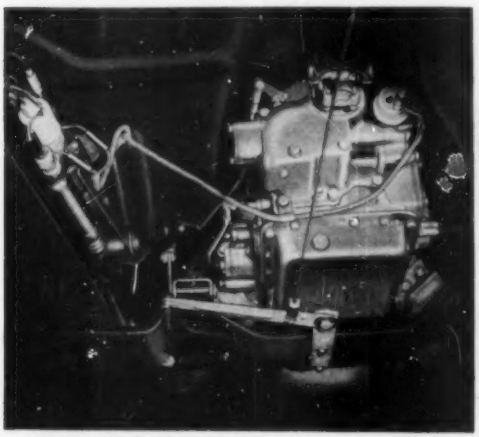


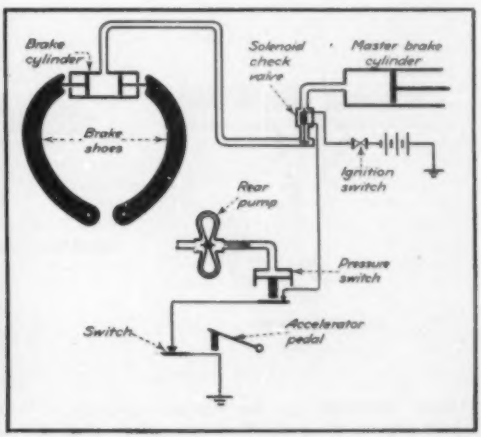
CONTROL SYSTEM uses pressure dome in combination with a restricted supply line to absorb hydraulic shock incidental to application of the servo units. A double-piston servo applies the reverse band. When the selector valve is shifted, pressure is delivered only to the forward section of the cylinder. After band clearance is taken up, pressure build up operates the shuttle valve. This admits pressure to the rear section, fully applying the band.



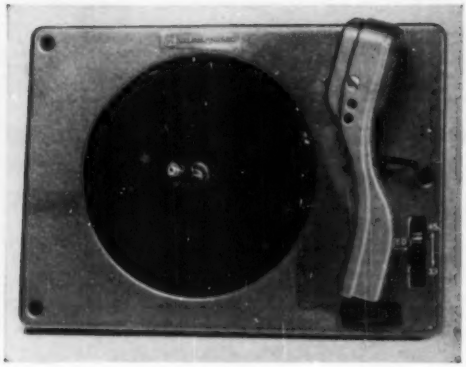
TWO FREE-WHEEL units or overrunning clutches are incorporated in the rear planetary set. As is characteristic of any simple planetary, locking any two members together causes the entire set to rotate as a unit. When any one member is held, the other two will rotate around it. If the two rotating members are adjacent, they move in the same direction. If they are alternate, they rotate in opposite directions. For example, in the intermediate range, the multiple disk clutch locks the sun gear with the planet carrier in the forward planetary set. Thus, this set rotates as a unit and delivers converter output to the ring gear of the rear planetary set without torque multiplication. The latter ring gear drives the planet carrier, which is connected to the rear axle. The front free-wheel unit idles over the cam, while the rear free-wheel unit holds the sun gear against the reaction of the planets.

The front free-wheel unit makes the rear planetary set irreversible in the intermediate range. Thus, if the car is allowed to come to a stop on an upgrade, it cannot roll back. The instant the car stops, torque is reversed on the planet carrier. Since the idling converter exerts a slight holding force on the ring gear and front free-wheel unit, the reverse torque on the planets is transmitted to the sun gear and cam. The tendency of the cam to reverse locks the front free-wheel unit. The rear wheels cannot roll back regardless of what force is applied to the car. Once the front free-wheel unit is locked, any amount of reverse torque on the cam is translated by the free-wheel unit rollers into an equivalent force that acts on the ring gear. The direction of this force is such that it helps the converter torque hold the ring gear stationary in space. If the selector lever is put in the neutral, low or reverse position, however, the car is free to move backward. Transmission uses 11 qt of 10w motor oil.

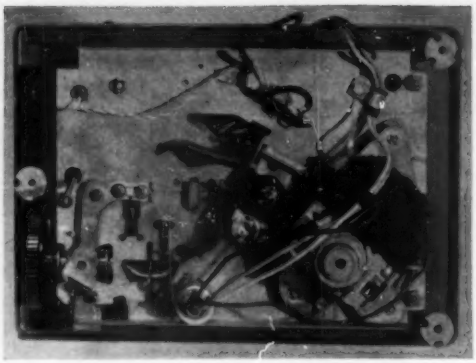




EVEN after the brake pedal is released, a solenoid-operated check valve retains 200 psi in the rear wheel brake cylinders to prevent car from creeping. The instant the accelerator pedal is depressed, a switch deenergizes the solenoid, fully releasing the brakes. This "anti-creep" device operates only when the car is at a standstill so that it does not interfere with normal braking. As long as the car is moving, a pressure switch, which is actuated by the rear pump, holds the circuit open. The picture at left shows the mounting of the check valve upon the car frame. Automatic up-shifting from intermediate to direct with the throttle wide open but not depressed past detent occurs at about 35 mph. When the throttle is wide open and depressed past detent, the transmission shifts to direct at about 58 mpr.



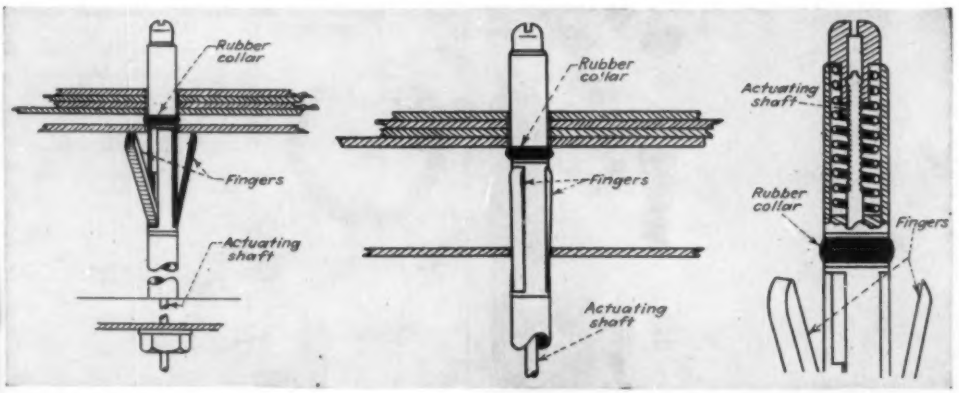
CHANGER SPINDLE accommodates the standard 9/32 in. center hole of the 33⅓ rpm record. To play the 45 rpm type, the 1½ in. diameter center hole of the record is plugged with a die cast washer. Use of this washer has the advantage of adding weight to the 45 rpm disk, thereby eliminating any tendency to slip.



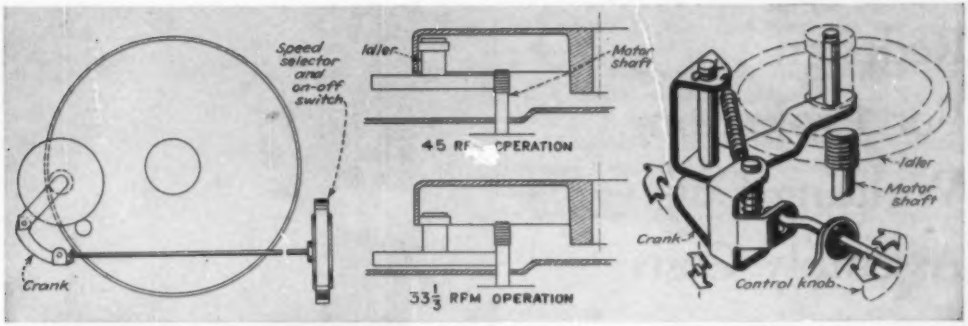
MOUNTING PLATE size, shape and dimensions were selected to make device interchangeable with existing changers that handle 45 rpm records only. The same mechanism is also available enclosed in a plastic case, with or without amplifier and speaker. A two-pole electric motor operates the changer.

Changer Mechanism Analyzes Rate of Tone Arm Advance

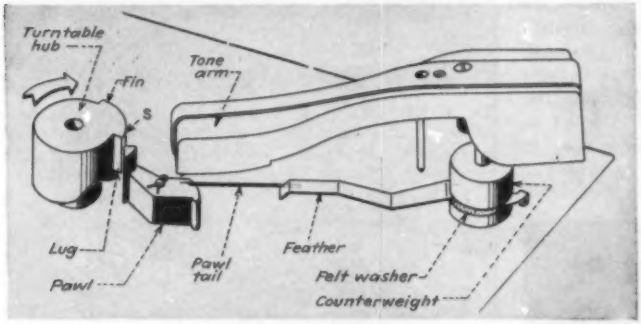
The "Duo-Seven" record changer was designed specifically for the new 7 in. slow speed records—both 33 1/3 and 45 rpm. Feature of the device is a "velocity-trip" mechanism that disregards the position of the tone arm and responds only to its speed of advancement. Thus, the changing cycle begins with a fraction of a revolution after the tone arm leaves the music modulated grooves and enters the fast-action track leading to the center hole.



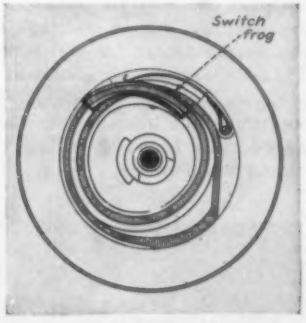
THREE FINGERS in the center spindle support the stack of records. When the actuating shaft within the spindle is pulled down, the rubber collar is compressed. This forces the collar into the stack, separating the bottom record from the rest. Up to this point, the fingers can spread slightly to accommodate the small movement of the bottom record. As the change cycle proceeds, a further downward pull on the actuating shaft retracts the fingers, dropping the record on the turntable. Then, the shaft is released. This spreads the fingers and releases the compression on the collar. This permits the remaining records to rest on the fingers until the start of the next cycle. The shaft acts on the collar through a compensating spring. This spring preloads the rubber to assure that wedging will begin the instant the shaft is pulled down—regardless of hole diameter which varies with wear. The Webster-Chicago Corporation of Chicago makes this fast action changer.



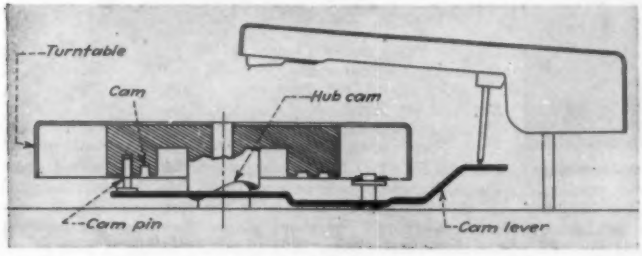
COMPOUND DIAMETER idler converts rotation of the small diameter motor shaft into proper turntable speed. Sketches in center above show idler positions for playing 33⅓ and 45 rpm records. In shifting the idler up and down during speed selection, the idler must be backed away from contact with both motor shaft and turntable before the shift takes place. This is accomplished by the crank motion sketched at the right. An advantage of this arrangement is that idler contacts either the motor shaft nor the turntable when the crank is in the center position. At this point, the motor switch is open. This design prevents the formation of hollow spots on the rim of the idler's rubber surface while the machine is not in use. These hollow spots introduce noise into the sound system. The control knob used for changing speed also actuates the on-off switch.



CHANGER MECHANISM responds not to tone arm position but to its rate of travel. As tone arm advances slowly during the playing of a record, the feather moves with it. Connection between tone arm and feather is frictional, through the counterweight pressing against the felt washer. In turn, feather rotates the pawl through the pawl tail. However, the turn table hub carries a cam shaped lug that has a shorter radius at "S" than at "FIN". With each revolution, the lug pushes the pawl and feather back to their original position. Thus, feather has a receding relationship with the tone arm. But when tone arm contacts a velocity groove and advances suddenly, the pawl will engage the lug's driving face. This swings the pawl around, starting the change cycle.



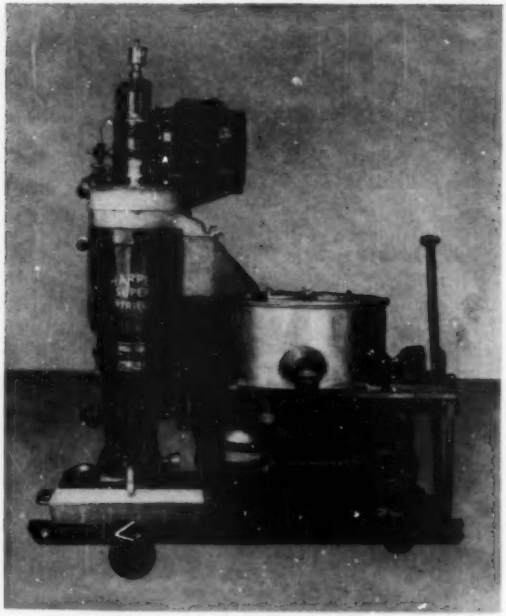
TWO-REVOLUTION CAM that controls changing operations is integral with zinc die cast turntable. When designers considered the many motions involved, they decided that one revolution of the cam would be too rapid for smooth action. The two revolution cam sketched above uses a one-way switch frog at the cross-over point to guide the cam pin.



CAM-PATH is three-dimensional, providing up and down as well as radial motion. When cam depresses the pin on the end of the cam lever, the tone arm is lifted from the record. Then, arm is shifted horizontally away from the turntable, held motionless for a moment and returned to the starting position. A second cam surface is cut into the turntable hub where maximum torque is available for pulling the actuating shaft that compresses the rubber disk.

Redesign For Projection Welding Cuts Assembly Costs

Engineers of the Sharples Corporation of Philadelphia maintain a definite schedule for reviewing the design of their products. Their aims are improved performance, longer life, faster production and lower manufacturing costs. Every component—large or small—of any given product gets its share of attention. Recently, for example, the drip pan of a big Sharples centrifuge was brought up for discussion. Although the drip pan is a minor part of the apparatus, the changes made in its design resulted in savings of $860.00 for every 1,000 units produced. The centrifuge is used in purification of various types of liquids, including machine tool cutting oils. The apparatus, which is mounted on a hand truck, can be moved easily to liquid storage tanks spotted in various plant locations.



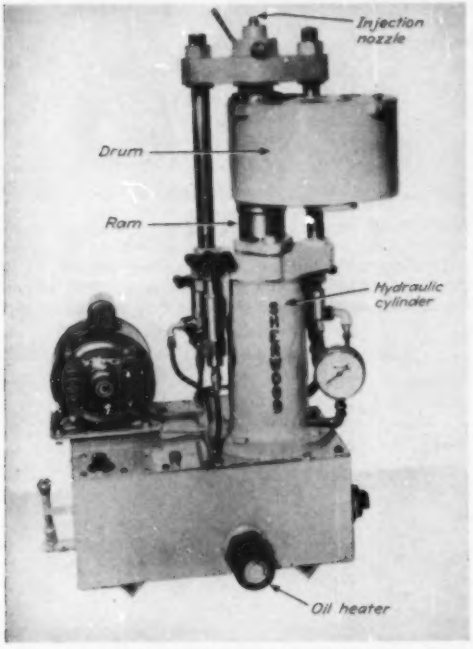
AN AUXILIARY PUMP transfers the liquid into the centrifuge which spins out impurities and returns liquid to the storage tank. Accumulated impurities are drained into drip pan through tap in the bottom of the centrifuge section.

PARTS are projection welded to pan in this machine. Operation is rapid and parts can be accurately positioned without special jigs. The Ohio Nut & Bolt Company of Berea, Ohio, suppliers of the handles and feet, designed them especially for projection welding.

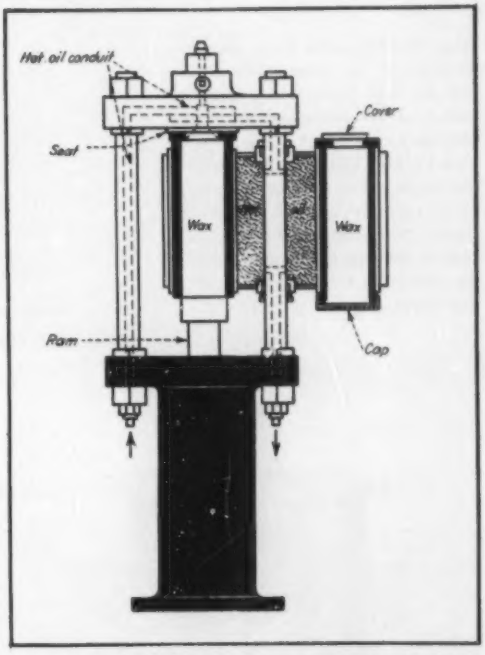
HANDLES AND FEET were involved in drip pan redesign. Originally, these parts were arc welded to the pan. Because of their small size, welding of the parts was difficult and time-consuming. The above picture shows the pan handles and feet after redesign for projection welding.

Drum Feed Lowers Cost of Wax Injection Pump

This Sherwood Injection Press pumps wax into molds for the volume production of investment casting patterns. The press uses a rotable drum to feed wax slugs to an hydraulic ram for injection. This design was adopted to permit rapid loading, save cost and keep overall height to a minimum. If only one wax cylinder were used, a means would be required for raising the yoke or lowering the ram to permit top or bottom loading. Alexander Saunders & Company, N.Y.C., makes it.



HYDRAULIC RAM acting within the drum cylinders provides the pressure for wax injection. Each cylinder is 3½ x 8 in. with a volume of 78 cu. in. While the wax is being discharged from one cylinder, wax in the other cylinders is being softened. A 10 gal pump circulates hot oil around the cylinder walls to heat the wax slugs.



SNAP-ON COVERS at the bottom of each cylinder prevent softened wax from sliding out. When a cylinder is rotated into place over the ram, its cover is removed manually. As ram rises, it pushes the cylinder sleeve upward against a self-sealing seat. The sleeve is pulled free of this seat by the ram before drum is rotated.

High-Cycle Motor Simplifies Concrete Vibrator

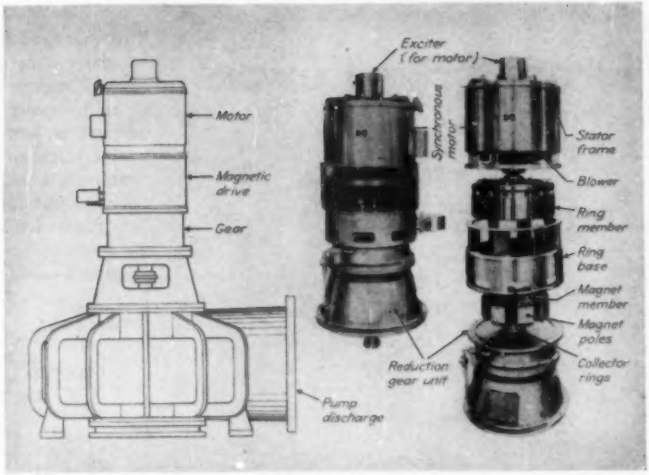
SPECIAL ELECTRIC MOTORS are not necessarily more expensive than standard types—provided the overall cost of the entire assembly is taken into consideration. For example, Robbins and Myers recently was asked to design induction motor of better than 1.0 hp capacity that would (1) fit into a housing of 2½ in. outside dia or less, and (2) operate at approximately 10,000 rpm with a direct drive. It was to drive an eccentric weight in a concrete vibrator, which is submerged directly in fresh concrete to consolidate and compact it.

The unit developed for this application operates on 180 cycle a-c current. The iron stack is 4 in. long and 2⅛ in. in diameter. The rotor is 1.0 in. in dia, and is made of solid copper bars. The winding is glass insulated. The motor has no fan, heat being carried by convection through the tubular shell into the concrete, which acts like a fluid.

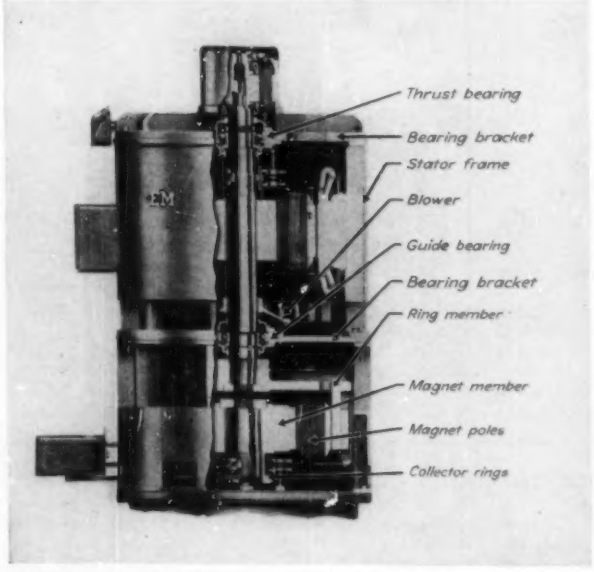
By incorporating the motor in the vibrator housing, expensive and troublesome flexible shafts are eliminated. And by using a 180 cycle induction motor, the desired speed of 10,000 vibrations per minute is obtained with no gearing; the only wearing parts on the machine are the ball bearings, there being no brushes or commutator.

Synchronous Motor Drives Pump

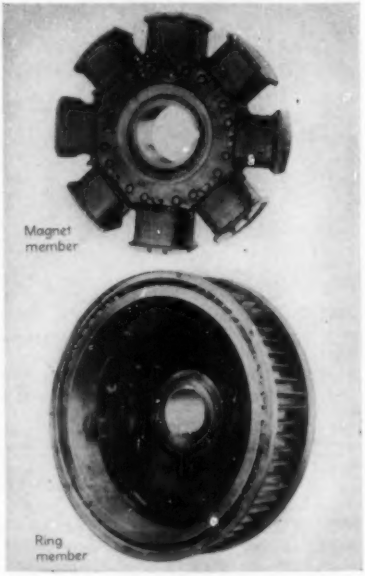
This variable-speed pump assembly is intended for installations requiring the high power factor and efficiency of synchronous motors. Although motor speed is fixed, pump speed is not. Designers got this flexible performance by installing a magnetic coupling between motor and pump. By changing the exciting current in the coupling, pump speed can be varied from 20 to 97 percent of synchronous speed.



SYNCHRONOUS MOTOR of standard vertical design is mounted above the pump. A thrust bearing in the bottom of the stator frame carries the weight of the motor rotor and the magnetic coupling. This coupling consists of two rotating elements—the ring member and the magnet member. The magnet member revolves within the ring member and is separated from it by an air gap.



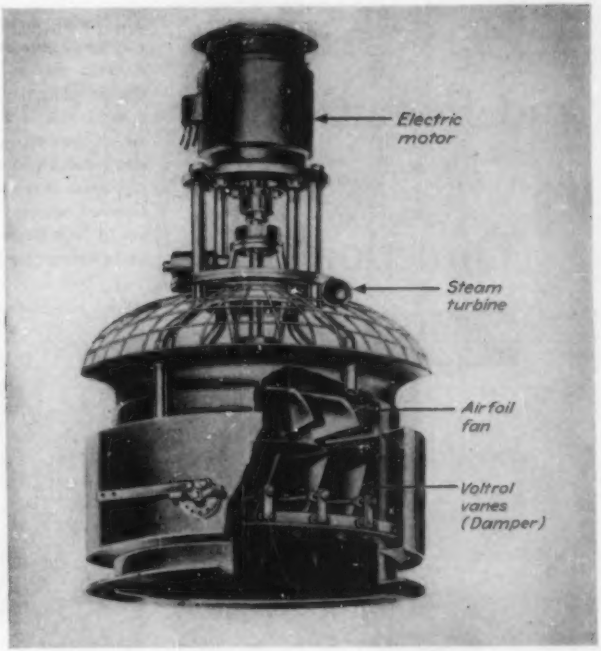
COLLECTOR RINGS transmit excitation current to the magnet coils. Increasing excitation current decreases slip between ring and magnet members, which in turn raises the pump speed. Because of its surface projections, the ring member acts as an effective blower for cooling the magnetic drive. A separate blower in the upper housing takes care of motor cooling. The Electric Machinery Manufacturing Company of Minneapolis makes the Magnetic Drive in ratings from 25 to 1550 horsepower.



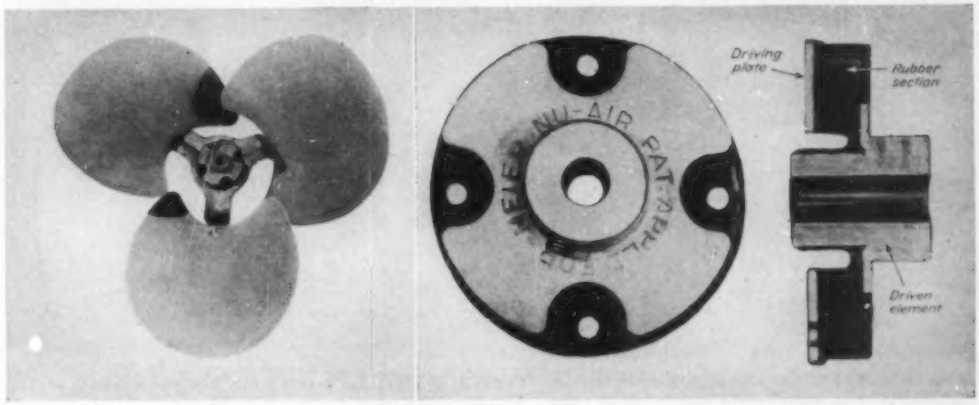
KEYED and tapered bores of the ring and magnet members mount on the shafts of the motor and pump respectively. Direct current flowing through the magnet coils sets up flux fields. As the magnetic lines are cut by the ring, induced currents establish magnetic poles in the ring which pull the magnet member into rotation.

Steam-Electric Drive For Blower

A steam turbine and an electric motor are connected in tandem to the rotor shaft of this industrial blower. Either motor or turbine can drive the blower at full rated output. Object of this design was to produce a unit which could take advantage of the efficiency of a steam turbine and yet not be entirely dependent on the availability of steam. Whenever the steam supply is shut down, throwing a switch puts the motor into operation. Four bent steel tubes support the totally enclosed motor above the turbine and blower. The tubes also serve as braces for the complete assembly. The L. J. Wing Manufacturing Co. of New York City makes the Dual Drive Forced Draft Blower in sizes ranging up to 40,000 cfm of air.



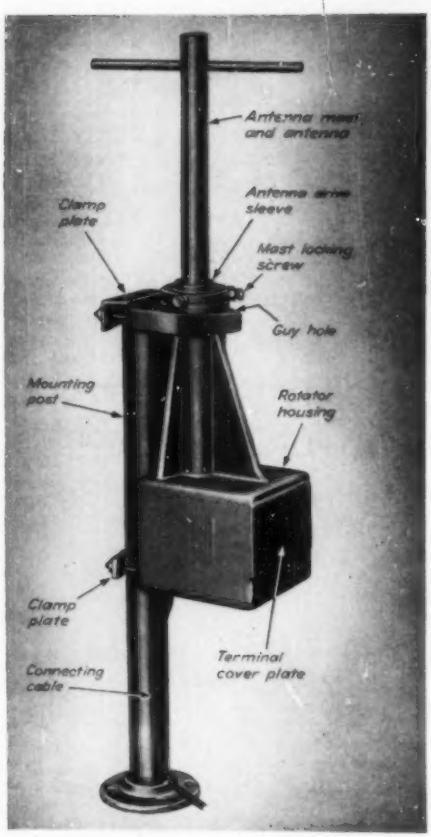
Rubber Hub Eases Specifications for Fan Motors



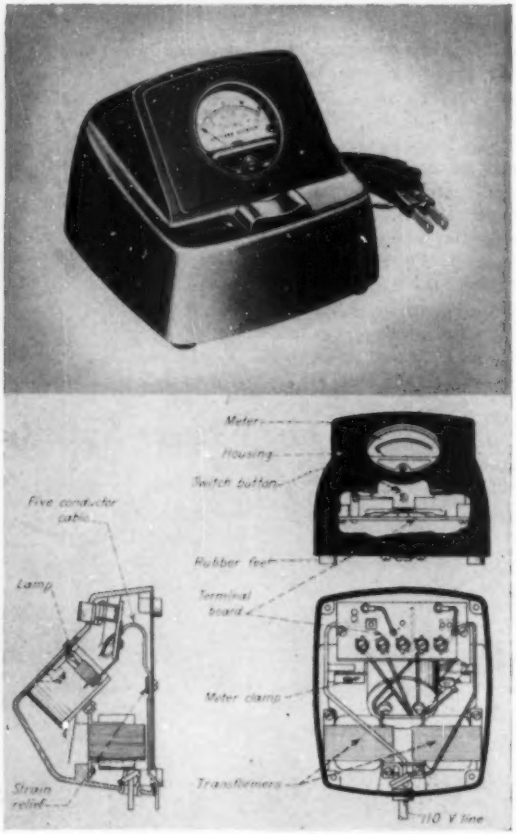
NEW HUB introduces rubber in shear between driving motor and fan blade. The purpose is to stop transmission into the propeller structure of torsional and magnetic vibrations originating in the motor. These vibrations are directly related to motor design and cost. With conventional hubs, the most economical—and otherwise completely satisfactory—motors produce annoying fan noise. For this reason, low-priced motors could seldom be used. Since the rubber hub eliminates this condition, cheaper motors can be specified in fan design. The Meier Electric and Machine Company of Indianapolis makes these hubs. Hub for large fans has steel driving element and a steel driven plate connected through a rubber section that is molded in place. Dimensions of the rubber must be held within close tolerances since any degree of compression reduces vibration absorption.

Ammeter and Potentiometer Make Simple Direction Servo

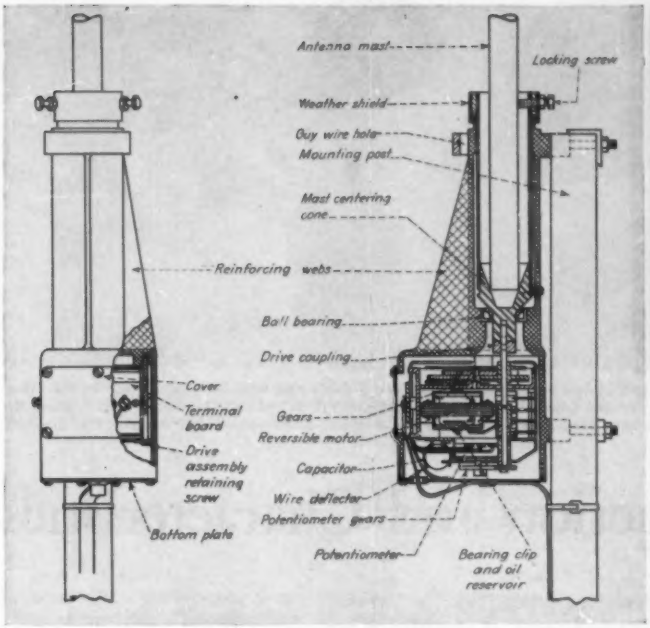
The facing direction of a roof-mounted television antenna can be changed at will by the use of the Crown Antenna Rotator. Control of antenna rotation is through a small unit that is placed on or near the TV set. One feature of the control unit is a dial indicator that shows the direction in which the antenna is orientated. In place of using expensive servo mechanisms for the indicating function, the design engineers developed a simple electrical circuit to do the job. Crown Controls Company Incorporated, makers of the rotator, are in New Bremen, Ohio. Connections between control unit and antenna installation are made through a 5 conductor cable.



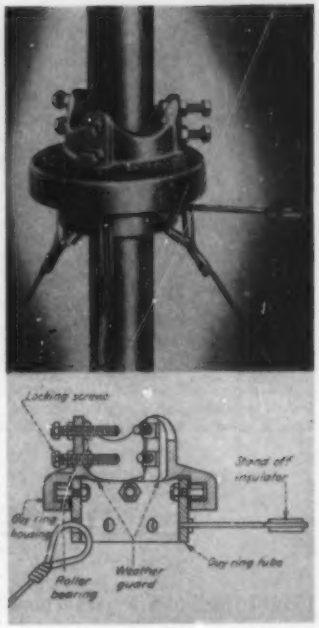
WEATHERPROOF cast aluminum housing encases the electric drive motor and reduction gears. The design of this casting is a compromise between weight and strength to satisfy two extremes of mounting requirements. Drive unit must be light enough for top-of-pole mounting. But some installations put the unit at the base of the antenna mast. In such cases, casting must be strong enough to support the entire vertical thrust of the mast. This may be as much as 175 pounds.



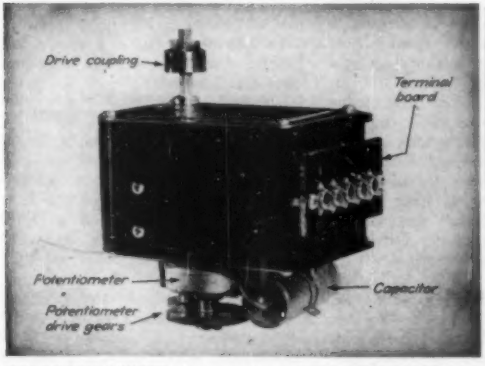
CONTROL UNIT has direction indicator and operating switch. In addition to being marked with the points of the compass, indicator dial is numbered. Numbers are more readily associated with the antenna direction that gives best reception for a particular channel. Indicator is basically an ammeter. It is connected in series with a wire-wound potentiometer located in the rotator mechanism. Two transformers mounted within the aluminum housing of the control unit supply reduced voltage to indicator and rotator circuits. These are 6 and 24 volts, respectively.



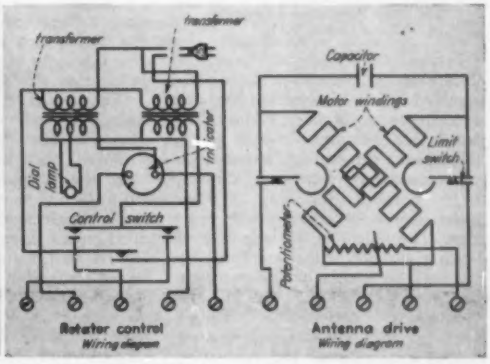
DRIVE MOTOR delivers torque to the reduction gearing of Rotator. The ratio of these gears is 2000:1. Motor is equipped with separate windings for forward and reverse. A full 360 deg rotation of the antenna requires about 45 sec. At the end of rotation, a switch opens the motor circuit. This eliminates the need for a mechanical stop, which would make it possible to overload the motor if the control button were not released.



ROLLER BEARING guy ring was developed to support the longer lengths of antenna mast. Mast can rotate freely within the ring, although it is rigidly held in the upright position. Lip keeps rain from roller bearing.



POTENTIOMETER is geared to the lower end of the drive motor shaft. Thus, as the antenna rotates, more or less resistance is placed in the indicating circuit. By measuring the current flowing in this circuit, the ammeter used for the direction indicator accurately detects antenna position. The drive assembly pictured above is substantially identical with the unit used by Crown Controls Co. on their automatic regulator for furnace dampers. The adaptation of this proven unit kept design and development costs of the antenna rotator to a minimum.



LOW VOLTAGES are used in rotator circuits to simplify insulation problems on outdoor wiring. Control switch has 3 contacts. Two contacts are for forward or reverse motor operation. The center contact opens the line circuit when the switch button is released. Thus, all circuits are deenergized except when the antenna is being rotated. Internal brake stops antenna rotation as soon as control button is released. Thus, antenna cannot coast beyond the selected position. Brake also eliminates any tendency of the antenna to shift during high winds.

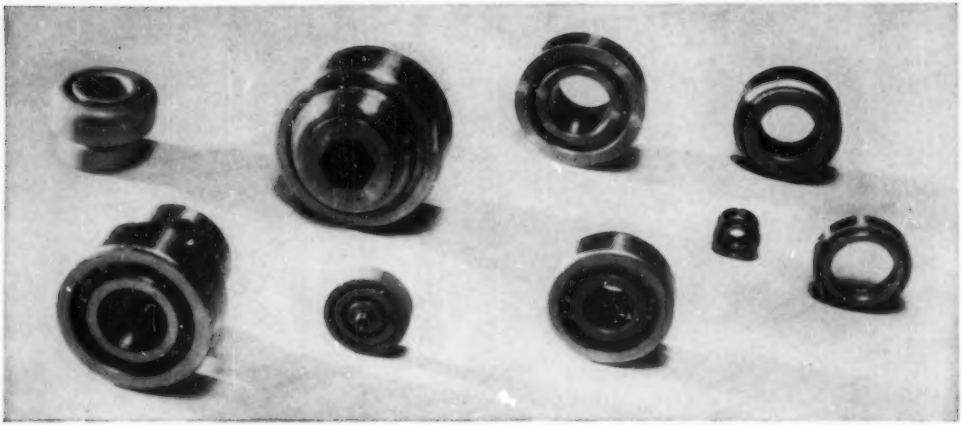


Fig. 1—Representative group of low cost, special ball bearings. One is designed with a nylon outer race, one has a hexagonal bore, a third is cadmium plated, while others have different design features that better suit them for the service conditions under which they are to operate. The cost of such bearings depends on the type of modification and on the quantities involved.

Construction and Characteristics

How to select low cost commercial ball bearings for various speed and loading conditions. Classification of standard types for radial and/or thrust loads. Modifications that can be made for special design, assembly, or operating conditions.

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Chief Engineer
The Schatz Manufacturing Company
Poughkeepsie, N. Y.

THE GENERAL TENDENCY among designers is to classify bearings into one of two groups: Sliding bearings, and anti-friction bearings. In each group, they classify the bearings according to types, such as precision ball and roller bearings, including straight-roller, tapered-roller, or needle bearings. The fallacy in this approach to bearing selection is that there may be two or more classes of any one type, i.e., precision bearings or low-cost "commercial" anti-friction bearings; often the latter will satisfactorily meet design specifications, and cost from one-fourth to one-sixth as much as a precision type. Particularly is this true in the ball bearing classification.

Precision ball bearings are those that conform to basic plans for boundary dimensions of metric or inch dimension bearings as established in recently approved standards by the Anti-Friction Bearing Manufacturers Association. Although they are eminently satisfactory for any equipment requiring anti-friction ball bearing performance, their disadvantage, for some applications lies in their high cost, which is a direct result of the close tolerances to which they are held during manufacture.

"Commercial" ball bearings, on the other hand, are those made to tolerances wider than those specified by the AFBMA. Such bearings usually are made without retainers or ball spacers and to inch dimensions rather than to metric dimensions; the races may be either ground or unground. Generally, they are used in applications involving lighter loads and slower speeds than the maximum at which precision types can operate. As a result, they are not generally used in machine tools, comparators, instruments, or other precision equipment, but rather for automotive components, conveyor rolls, certain business machine parts, household appliances, mining and excavating machinery, farm and marine equipment, tractors, toys, and similar equipment and devices. The average cost of precision ball bearings is four to six times that of commercial bearings of comparable dimensions. The cost of precision bearings in the small sizes increases as the bore decreases, because of the difficulty in maintaining the tolerances. In commercial ball bearings, the cost decreases in almost direct proportion to the size, since material is the dominant factor. In large quantities, special bearings can often be furnished at a cost not exceeding that of standard stock commercial bearings. In Fig. 2 is shown the actual relative cost of precision ball bearings and of ground and unground commercial types.

Construction of Commercial Bearings

Commercial bearings are of two general types, namely ground or unground. In unground types, the outer race is either machined on an automatic screw machine, or else cold formed to close limits on presses; the difference in the two types is shown in Fig 3. Inner and outer races are hardened and tempered. The balls are highly polished, hardened steel, dimensionally equivalent to a No. 3 chrome-alloy steel ball. These types are suitable for operating at moderate speeds and under moderate loads whenever the application does not require close tolerances.

If capacity must be higher than for unground bearings, several things can be done. First a machined bearing can be specified to obtain greater accuracy and rigidity, and to decrease the

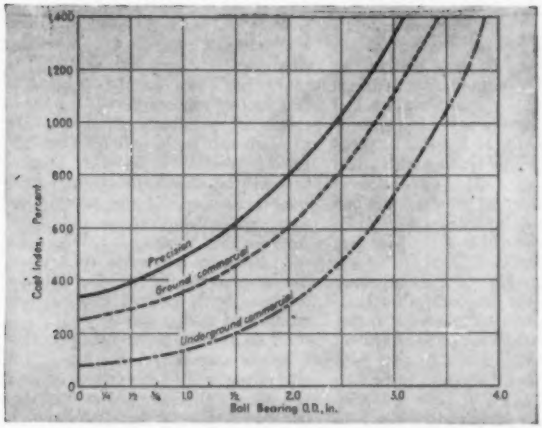


Fig. 2—Relative cost of precision ball bearings and of commercial ground and unground bearings. Cost of the precision type ranges between one and one-half and six times that of the ground or unground commercial types.

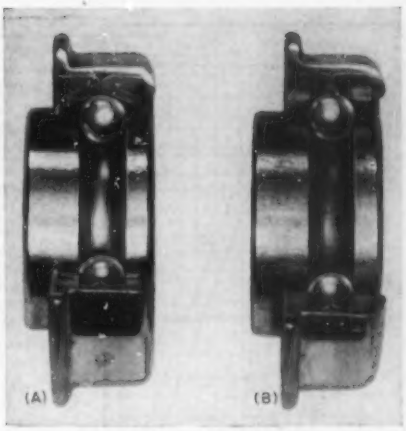


Fig. 3—Commercial ball bearings have machined (A) and cold-formed (B) outer race. Machined units distort less during heat-treatment and in service.

Of Low-Cost Ball Bearings

possibility of distortion during heat treatment. However, a machined outer race increases the cost of the bearing somewhat. Cost is further increased if the inner and outer races are polished or burnished to remove tool marks, which is a method sometimes used to increase the speed rating.

Grinding the inner and outer races increases the radial load carrying capacity of the bearing by approximately 2.17. Also, since the tolerances on ground types are on the order of only one-quarter of those specified on unground types, it is apparent that they are smoother running and better suited for higher operating speeds. Generally, unground bearings are limited to speeds of 1,000 rpm.

Commercial bearings also can be obtained with many other modifications or accessories. They may have a single-row or double row of balls, have labyrinth or felt seals to prevent entrance of dust or dirt, have flanged or plain outside diameters, be provided with a hardened or unhardened tread, or be equipped with set screws, Alemite fittings, and extended inner race, or a hexagonal bore.

The bearings are made for radial loads, thrust loads, or for combined radial and thrust loads, as shown in Fig. 4. Radial-type bearings will take a thrust load in either direction equal to 50 percent of the rated radial load, but combined radial and thrust loading should not exceed the rated radial load. Thrust-type bearings are rated for loads applied parallel to the shaft; they will not take any radial loads. On the other hand, combination radial-thrust bearings will carry equal amounts of thrust and radial loads in one direction only; while they are rated on the basis of radial capacity, they should not be used unless the thrust load is at least great enough to keep the inner race in proper contact with the balls.

Selection of Commercial Ball Bearings

The selection of commercial bearings, like precision types, is primarily a problem of relating the load capacity of the bearing to type and extent of loading anticipated, and to the operating speed of the bearing. The charts, Figs. 5 to 8, have been prepared to enable the selection of the smallest bearing that will carry the loads with a reasonable life expectancy. In a presentation of this nature it is possible to depict only a few of the most commonly used ball complements and bearing sizes. Literally thousands of variations appear in the manufacturer's drawings. But often the charts give a quick appropimation of the requirements if the bearing is a commonly used size.

The following example illustrates the use of the charts. Suppose that an unground bearing is to be used, and that the loads have been computed

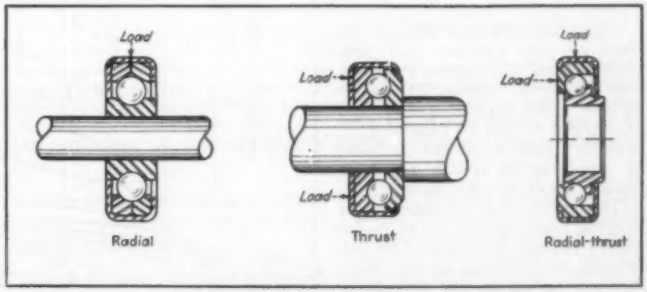


Fig. 4—Basic types of bearings classified according to kind of load that they are capable of carrying. The thrust bearing will not carry any radial load, while radial bearings will carry up to 50 percent of the rating as a thrust load.

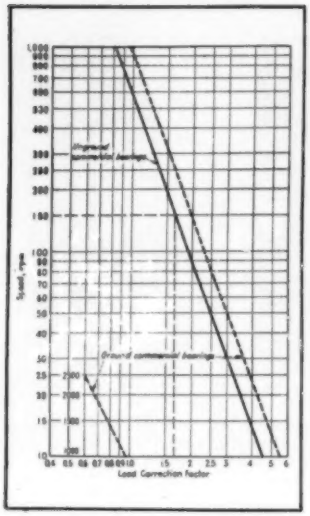


Fig. 5—Speed-load correction factors for ground and unground commercial bearings. Such a correction factor is often necessary because the life ratings of commercial bearings are based on an operating speed of 600 rpm, and different speeds either increase or decrease the size of the ball complement required to obtain satisfactory bearing life.

to be 290 lb in the radial direction and 40 lb in the axial direction. The arithmetic sum of the two loads (290 + 40 = 330) is the equivalent radial load.

Suppose also that the shaft will rotate at 150 rpm. Since unground commercial bearings are rated at 600 rpm, the equivalent radial load at 150 rpm must be converted to the equivalent radial load at 600 rpm. From the speed-load curves, Fig. 5, the load correction factor at 150 rpm is 1.65. The equavalent radial load of 330 lb then is divided by 1.65 to find the loading at 600 rpm, which is 200 lb.

The curves in Fig. 6 indicate that there are two minimum ball complements that will support this load: one consists of between 12 and 13 balls of $\frac{5}{16}$ in. diameter, and another, of between 19 and 20 balls of $\frac{1}{4}$ in. diameter. These conditions are found by projecting the 200 lb load point horizontally across the curve.

The approximate maximum bore is found from Fig. 7 to be $1\frac{1}{16}$ in. for the $\frac{5}{16}$ in. ball complement; for this bearing, the minimum outside diameter will be 2.0 in. For 20 balls of $\frac{1}{4}$ in. diameter, the approximate maximum bore will be $1\frac{3}{16}$ in. and the approximate minimum outside diameter will be $2\frac{1}{4}$ in. From the manufacturer's catalogs, the bearing having the dimensions closest to those desired can be chosen. For example, the bearings having a (13) $\frac{5}{16}$ in. diameter ball complement have a bore of $\frac{5}{8}$, $\frac{3}{4}$, or $\frac{7}{8}$ in. and an O.D. of 2.0 in., as listed in one catalog; the bearing with a ball complement of (20) $\frac{1}{4}$ in. diameter balls is not listed as standard, but one having (21) $\frac{1}{4}$ in. balls and an O.D. of $2\frac{5}{16}$ in. is available if the boundary dimensions are suitable.

Next, from Fig. 6, it is necessary to determine the load ratings for bearings of these ball complements so that the average rated life can be estimated. The load rating for the bearing with (13) $\frac{5}{16}$ in. balls is found to be 210 lb; that for (21) $\frac{1}{4}$ in. balls is 215 lb. Dividing the actual load by the load rating results in ratios of 0.95 and 0.93 for the two bearings, which are equivalent to an average life rating of 4,000 and 4,500 hr respectively on Fig. 8. The choice between the two bearings then can be made on the basis of relative life requirements and first cost.

If it is proposed to use a ground commercial bearing, it is neccesary only to divide the computed radial equivalent load by 2.17 and proceed as outlined above. If the axial or thrust load is greater than 50 percent of the radial load or if the load is predominantly thrust, a radial-thrust bearing or straight thrust bearing should be used; in this case, consult the manufacturer's engineering department.

The load ratings given by these charts are for fairly constant operating conditions of load and speed. The charts are based on the assumption that bearing mounting will be correct, that there will be equal distribution of load, that there will be clean operating conditions, and that lubrication will be correct. Also, shaft rotation is assumed. If the housing rotates, ball speed increases and therefore, the load capacity is reduced. To compute load ratings in such cases, the actual operating speed should be increased by 50 percent, and the load rating used at that speed.

Of course, the problem of selecting a proper commercial bearing is not always confined to the factors of load and speed. Design practice may dictate that a ground shaft of a certain size should be used and that, except for the cut-off, no other machining operations should be performed. The bearing whose bore fits the shaft may have more than ample capacity to meet the load requirement, but its purchase may prove more economical than additional machining operations. The installation of a shaft and its components through the bearing housing may mean the difference between profit and loss.

Thus the selection of the bearing will, within reason, be governed by the size of the shaft components that must pass through the housing. This does not mean that the loads and speeds should be ignored. The design engineer should always be sure that

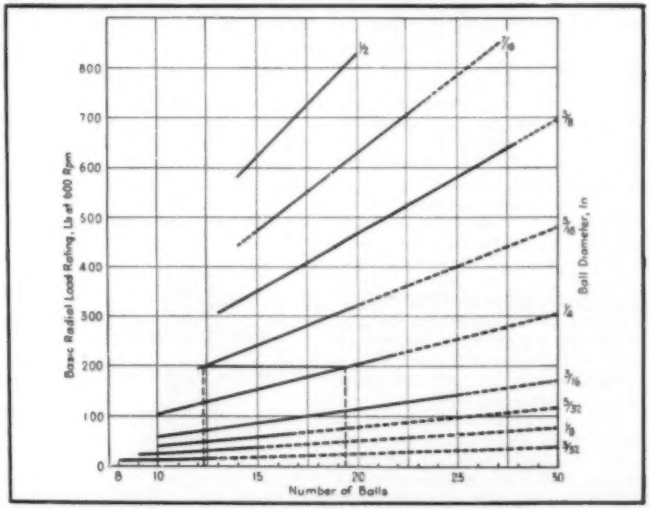


Fig. 6—Load rating at 600 rpm of various ball complements used in unground plain and flanged commercial ball bearings. The solid lines represent commonly used ball complements, of course, other variations can be obtained and even may be standard.

the bearing has ample capacity to give a reasonable bearing life and secure a further assurance by asking the manufacturer to approve the selected bearing for the application.

Special Bearings

By analyzing the individual requirements of an application, the designer often may be able to specify a special bearing type that (1) will cost less than other types but will still meet performance specifications; (2) will be easier to assemble than standard types; or (3) will simplify the design of the assembly in which it is to be mounted.

Just what is meant by a special bearing? It may be only slightly different from a standard bearing, or all the basic elements may be modified. It might be loosely defined as one not regularly carried in the bearing manufacturer's stock. The tentative standards of the AFBMA defines special and special line bearings as follows:

SPECIAL LINE bearings are those bearings where external or boundary dimensions are not in agreement with basic plans for boundary dimensions but are produced by one or more manufacturers as a more or less complete series.

SPECIAL bearings are those bearings not meeting the requirements of the definitions for standard or special line bearings.

However, in this discussion a special bearing will be considered as one that has in some way been modified too meet the specific requirements of a particular application—a somewhat broader definition than that proposed by the AFBMA.

Materials Modifications

The most obvious modification of standard bearings, other than those previously discussed is in materials. Changing from a carburizing grade low carbon steel to a through hardened type increases the load rating about 4 times.

Of course, as the grade of material is improved, the cost of the bearing increases. In addition, scrap formed during the machining and grinding operations represent a greater loss, and the number of bearings that can be machined in any given period is considerably reduced. This increase in cost is in proportion to the size and type of bearing, and thus is almost impossible to estimate in a general way. However, when load carrying capacity—not corrosion resistance—is the primary consideration, it may be more economical to add another ball track than to change the material. This change will increase the load rating of the bearing only about 1½ times—not twice, as might be expected, because it is almost impossible to get two ball tracks that will divide the load equally.

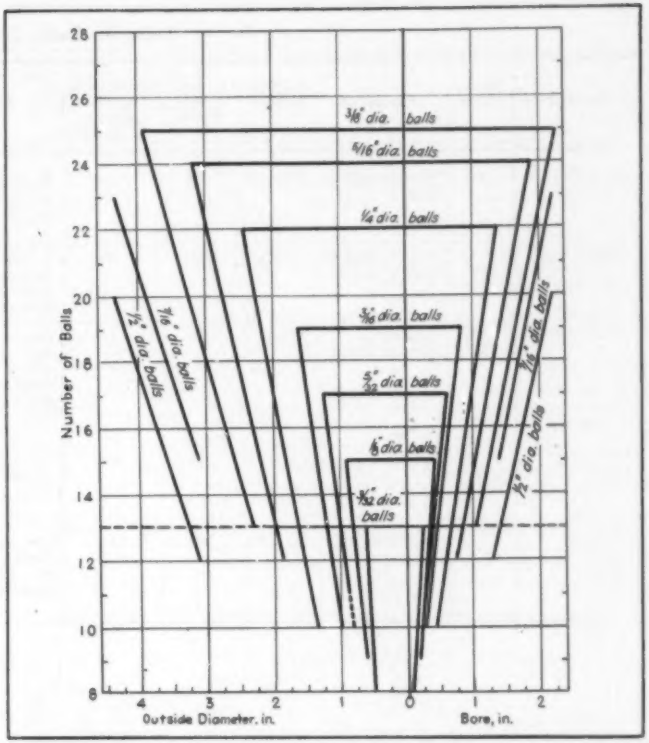


Fig. 7—Approximate maximum bore and minimum outside diameter of commercial plain and flanged unground ball bearings. The chart is less accurate for ground units.

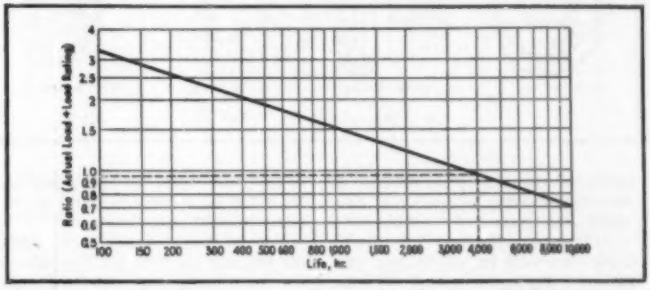


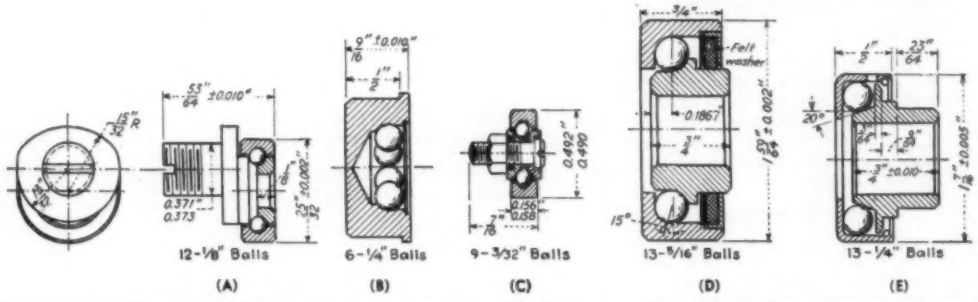
Fig. 8—Average life rating of commercial bearings, based on the ratio of actual service load to bearing rated load. When there is a choice between the bearings for the same application, the one with the highest load rating will give the longest length of service, but first cost may govern the selection. These factors must be weighed by designers.

Special materials and plated or treated bearings are more frequently used when atmospheric conditions are corrosive or when service temperatures are severe. Cadmium-plated carburized steel parts are relatively inexpensive, although cadmium plating is almost always limited to protection against weather conditions, against corrosion, or for decorative appeal. A typical application is on washing machine wringer rolls, as shown Fig. 1. A black oxide finish also can be, and often is, used.

For more severe conditions, as en-

Table I—Some Typical Special Bearing Applications

Modification	Bearing Design	Application	Number of Balls	Operating Speed (RPM)	Approximate Capacity at Operating Speed (lb)	Requirement	Solution
Inner Race	(A)	Elevator carriage door	12 (1/8")	100	55	Bearing that could be adjusted to compensate for roller wear.	Eccentric made in one piece, inner face of which rolls on balls. Slight rotation of eccentric changes position of roller.
	(B)	Pivot bearing for folding machine	6 (1/4")	2000	39	A low cost, rugged thrust bearing of simple construction that could be easily maintained.	A shaft designed to serve as inner ring, thus reducing assembly time and providing for a maximum thrust load.
	(C)	Typewriter carriage bearing	9 (3/32")	600	12	Bearing whose width could be adjusted to control end play, that would be easy to mount, and would be extremely rigid.	Bearing with split inner ring separated by soft spacer and held together with bolt that can be tightened or loosened, within limits, to vary width. Four points of contact for balls provide maximum rigidity.
	(D)	Television aerials	13 (5/16")	25	65	Sealed, low cost bearing capable of taking both thrust and radial loads.	General purpose design with felt seals and two points of ball contact. Can be used also for other applications, such as stokers.
	(E)	Lawn Mower	13 (1/4")	500	135	Low cost bearing that would take up end play and could be easily assembled.	Bearing designed for three points of contact, one on inner race and two on outer race. Inner race held in place by wire retainer ring. Bearing will not carry radial loads



countered in the photographic or chemical industry, hardenable or non-hardenable grades of stainless steel —AISI types 440C and 302, respectively—are used for all bearing components. Type 302 is used when excellent corrosion resistance and/or non-magnetic properties are desired; type 440C, in the hardened condition, has better load carrying characteristics but is not equivalent in corrosion resistance.

Both of these types are good for temperatures up to 350 F. For temperatures above this point, high-speed tool steel is recommended instead. Parts made of this material usually are drawn at 1100 F, and then polished. Rigid limits on service life at elevated temperatures have never been established, but one type of bearing made of high-speed steel has been operating for 5,200 hr at 800 F with no indications of reduction in hardness.

For quietness of operation, when the bearings are to be used as rollers, the outer rings can be fitted with threads made of hard rubber, Micarta, bakelite or nylon. Rollers for show cases, filing cabinets, desk drawers, and similar applications often are made from such materials.

Modifications in Construction

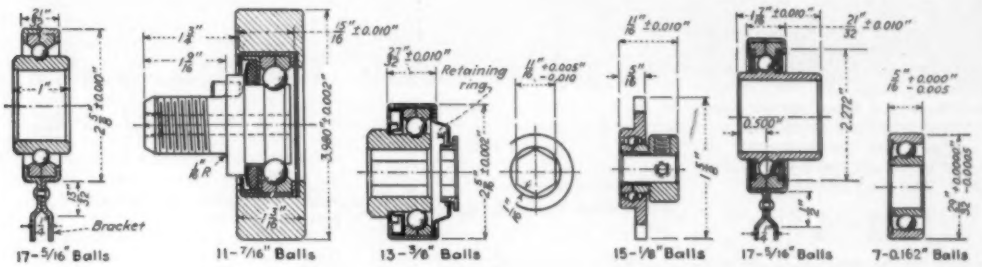
In designing a special ball bearing, or modifying a standard type to meet a particular need, three other basic elements may be changed:

1. The inner race
2. The outer race
3. The ball arrangement

Insofar as loading is concerned, the biggest gain is obtained by increasing ball size or by using a one-piece inner race and one-piece outer race together with a retainer in order to equalize the load on the balls. Runout becomes practically nil, and with solid races, the bearing approaches the accuracy of a precision ball bearing.

Yet other means of increasing capacity have been used by manufacturers of special ball bearings, when space or cost restrictions prevent the use of double-row or larger single-row bearings. In a typical instance, a conveyor bearing subject to shock loads was given extra capacity by machining the outer race from solid bar stock and spinning over an extra large section of the metal. In this way the cups were prevented from spreading under shock

Modification	Bearing Design	Application	Number of Balls	Operating Speed (RPM)	Approximate Capacity at Operating Speed (lb)	Requirement	Solution
Materials	(F)	Overhead conveyor	17 (5/16")	50	690	Bearing that would withstand very severe temperatures with very little lubrication.	All parts made of high speed steel drawn to 800 F.
Outer Race	(G)	Trolley wheel	11 (7/16")	50	870	Sealed bearing capable of withstanding heavy shock loads.	Outer ring machined from solid bar stock, leaving extra large section of metal to spin over—special seal constructed.
	(H)	Conveyor Bearing	13 (3/8")	100 (Intermittent)	545	Bearing that would fit a hexagonal shaft, could hold large amounts of grease.	Special floating shield designed to fit shaft
	(J)	Textile spool bearing	15 (1/8")	2500	20	Bearing that could be fitted without distortion and at a low cost.	Slotted flange made integral with outer ring—eliminating welding of washer to ring.
Other	(K)	Hanger bearing for Wood Drying Machine	17 (5/16")	75	56	Protected bearing to which bracket could be easily assembled.	Bearing equipped with felt seals. Mounting bracket made to form outer housing.
	(L)	Floor polisher	7(0.162")	5000	25	Quiet running and for higher than average operating speeds.	Outer race and inner race made of one piece. Less than a full complement of balls being used. The balls being spaced by means of a ball retainer.



loads, and, in effect, the capacity of the bearing was increased. However, because neither the number nor the size of the balls was affected, the tabular rating of the bearing remained the same.

However, the major reason for changes in construction is for design simplification of the assembly into which the bearing is to be fitted.

INNER RACE MODIFICATION. A typical example of inner race modification is the special bearing engineered for a manufacturer of office equipment. In this instance, a soft compressible spacer was placed between the inner race halves to control bearing end play on a typewriter-like carriage.

To save space and cost in the mounting of a heavy duty roller for an overhead door, the mounting pin was made integral with the inner race thus, becoming the shaft of the bearing, saving assembly time and cost as well as simplifying manufacturing procedure. Along the same lines, an eccentric roller used in an elevator carriage was designed with the eccentric in one piece, forming one half of the inner race, making position adjustment easy in compensating for wear on the roller. These and other modifications are illustrated by the bearings shown in Table I.

OUTER RACE MODIFICATION. A large textile manufacturer had been using an unground bearing to support the thread spools on a large weaving machine—an extremely low-load, moderate-speed operation. To this standard bearing the manufacturer had been spot-welding a slotted washer to hold the spool. The heat of the spot-welding operation often distorted the balls or races, and many bearings were scrapped. The bearing was changed from one in which the outer race was split and the washer welded to the case, to one with a split inner race and a special flanged outer race to replace the washer. The saving was not only in the elimination of rejects, but also in the immediate use of the bearing without the spot-welding operation.

A saving of space in the assembly of a pulley bearing was accomplished by a special bearing in which the pulley was made integral with the outer race, thus permitting the use of a ball

bearing in space which had seemed far too limiting.

ARRANGEMENT OF BALLS. Changes in the arrangement of balls consist of providing 2-point, 3-point, or 4-point mounting. In a bearing with 2 points of contact, there are only two points on each ball that are in contact with the race, *D* and *L*, Table I. A 3-point contact bearing is the standard, with a single contact point at either the inner race or outer race and double contact points on the opposite outer race, *H* and *K*, Table I. Four-points of contact sketch *C* are used only when extreme rigidity is necessary and when the best anti-friction operation is of secondary importance.

Of course, special bearings are practical only if the anticipated production rate is sufficiently high to justify the additional tooling cost required to produce them. The minimum production run on any one bearing usually is on the order of 1,000. The average quotation is on lots of ten, twenty, or thirty thousand units, but these figures vary widely with the type of modification that is involved. For example, if the modification involves a change only in the length of the inner ring or the diameter of the bore, not too much is involved in the way of tooling costs. If however, the modification requires a major change in the design of punches and dies, or means a big change in the outside dimensions of the bearing, larger production quantities are required.

Set-up time is also a factor. If individual lots are so small that only one day is required to turn out the part on an automatic screw machine—which might require two or three days to set-up—then special bearings might not be practical.

Calculation of a Practical Gear Ratio Approximately Equal to a Given Decimal

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A PRACTICAL GEAR RATIO approximately equal to a given decimal can be calculated by writing the decimal in a form known as a continued fraction. From this continued fraction, it is possible to get a number of gear ratios approximately equal to the decimal. From these gear ratios, the one which is most practical can be selected.

Suppose that the gear ratio expressed by the decimal 3.142 were required. The exact ratio is

$$\frac{3,142}{1,000} = \frac{1,571}{500}$$

To carry out the reduction in one stage would require a gear with 1,571 teeth and a pinion with 500 teeth. This would require an impractical number of teeth on the gears. To carry out the reduction in two or more stages would require finding two or more gear ratios whose product is 1,571:500. Since 1,571 is a prime number, at least one of the gears would still have 1,571 teeth. For this reason, it is desirable to use a gear ratio approximating 3.142, to make possible the use of gears with more feasible numbers of teeth.

Such a gear ratio can be calculated by continued fractions. To do this, it is first necessary to express the decimal as a continued fraction in the following manner:

$$\frac{3,142}{1,000} = 3 + R_1 \text{ where } R_1 = \frac{142}{1,000} \quad (1)$$

$$R_1 = \frac{142}{1,000} = \frac{1}{\frac{1,000}{142}} = \frac{1}{7 + R_2}$$

$$\text{where } R_2 = \frac{6}{142} \quad (2)$$

$$R_2 = \frac{6}{142} = \frac{1}{\frac{142}{6}} = \frac{1}{23 + R_3}$$

$$\text{where } R_3 = \frac{4}{6} \quad (3)$$

$$R_3 = \frac{4}{6} = \frac{1}{\frac{6}{4}} = \frac{1}{1 + R_4}$$

$$\text{where } R_4 = \frac{2}{4} \quad (4)$$

$$R_4 = \frac{2}{4} = \frac{1}{\frac{4}{2}} = \frac{1}{2 + R_5}$$

$$\text{where } R_5 = 0 \quad (5)$$

Substituting for R_1, R_2, R_3, R_4, and R_5 gives (6)

$$3.142 = 3 + \cfrac{1}{7 + \cfrac{1}{23 + \cfrac{1}{1 + \cfrac{1}{2}}}}$$

The expression on the right hand side is known as a continued fraction.

With the continued fraction determined, it is possible to approximate it by fractions known as the convergents to the continued fraction. The first convergent is obtained by letting $R_1 = 0$ in Eq (1); the second convergent is obtained by letting $R_2 = 0$ in Eq (2) etc. Thus the convergents are:

$$\text{First} = 3 = 3{:}1 = 3.00000$$

$$\text{Second} = 3 + \frac{1}{7} = 22{:}7 = 3.14286$$

$$\text{Third} = 3 + \frac{1}{7 + \frac{1}{23}} = 509{:}162 = 3.14198$$

$$\text{Fourth} = 3 + \frac{1}{7 + \frac{1}{23 + \frac{1}{1}}} = 531{:}169 = 3.14201$$

$$\text{Fifth} = 3 + \frac{1}{7 + \frac{1}{23 + \frac{1}{1 + \frac{1}{2}}}} = 1,571{:}500 = 3.14200$$

Assume that the third, fourth, and fifth convergents are all sufficiently accurate approximations to the decimal 3.142. The practical aspects of each of these convergents can now be considered.

The third convergent is not practical. To carry out in one stage a reduction of 509:162 would require a gear with 509 teeth and a pinion with 162 teeth. Since 509 is a prime number, using more than one pair of gears would not avoid the necessity of a gear with 509 teeth.

The fourth convergent is practical. Using one stage would require a gear with 531 teeth and a pinion with 169 teeth. While this one stage reduction is not desirable, a satisfactory method of carrying out the reduction in two stages can be devised. 531 can be factored as 9x59, and 169 can be factored 13x13. Therefore

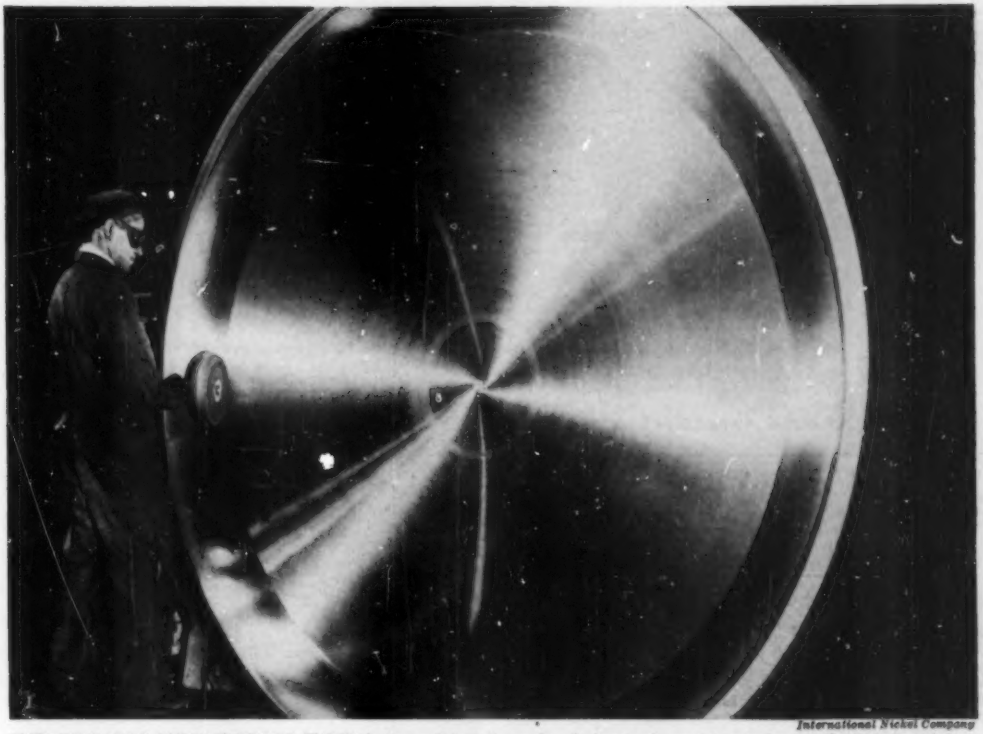
$$\frac{531}{169} = \frac{9}{13} \times \frac{59}{13}$$

Hence the 531:169 reduction can be accomplished by a 9:13 increase followed by 59:13 reduction. Another possibility is

$$\frac{531}{169} = \frac{18}{13} \times \frac{59}{26}$$

Thus the 531:169 reduction is obtained from a 18:13 reduction followed by a 59:26 reduction. This can be accomplished with gears containing reasonable numbers of teeth.

The impracticality of the fifth convergent, 1,571:500, has previously been discussed.



International Nickel Company

END OF LARGE MILK STORAGE TANK being polished is made of sheets of special spinning grade "18-8" stainless welded together and the welds ground smooth. Shape is achieved by mechanical spinning at Milwaukee Metal Spinning Company.

Austenitic and Special . . .

STAINLESS STEELS

Concluding a basic review of the corrosion resistant or stainless steels. After last month's discussion of metallurgical and property relationships, as well as specific descriptions of martensitic and ferritic types, this article gives properties, heat treatments and fabricating characteristics of the austenitic and special steels.

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ALL OF THE AUSTENITIC STAINLESS STEELS contain considerable amounts of nickel in addition to large amounts of chromium. The large percentage of nickel so stabilizes the austenitic phase that these steels are austenitic at room temperature and cannot be hardened by heat treatment (quenching). However, they harden by cold work, and the degree of such hardening generally increases with the total chromium plus nickel content. Depending on the amount of cold work, the tensile strength varies from about 80,000 psi for fully annealed to as high as 300,000 psi for severely work hardened steel; the highest strengths can be secured only with small cross sections. A stress-relieving treatment of about 1 hr at 750-800 F after severe cold working improves elastic properties without any adverse effect on ductility.

Table I shows composition limits, general properties and uses of the various chromium-nickel stainless steels. Since these steels are normally austenitic, they are also non-magnetic, particularly in the annealed condition. Cold work partially transforms austenite to ferrite; this in turn causes the steels to become somewhat magnetic, depending on the amount of cold work.

The austenitic steels have excellent cold forming properties and are extremely tough and ductile, even at low temperatures. In addition, they can

Table I—Composition, Properties and Uses of Austenitic (non-hardenable, non-magnetic) Stainless Steels

AISI Type No.	Percent				General Properties and Uses
	C	Cr	Ni	Other Elements	
302	0.08–0.20	17.0–19.0	8.0–10.0	.....	A readily fabricated stainless steel for trim, household utensils, structural, decorative or corrosion-resistant use.
303	0.15 max	17.0–19.0	8.0–10.0	P, S, or Se, 0.07 min Zr or Mo, 0.60 max	Free-machining variety of type 302.
304	0.08 max	18.0–20.0	8.0–11.0	.....	Low-carbon variety of type 302, weldable with less susceptibility to intergranular embrittlement.
305	0.12 max	17.0–19.0	10.0–13.0	.....	Low rate of work hardening because of high nickel content. Suitable for spinning, drawing and cold heading.
309	0.20 max	22.0–24.0	12.0–15.0	.....	For use at elevated temperature, combining high scaling resistance and good strength.
310	0.25 max	24.0–26.0	19.0–22.0	.....	Similar to type 309, with higher nickel content for greater stability at welding temperatures.
316	0.10 max	16.0–18.0	10.0–14.0	Mo, 2.00–3.00	Superior resistance to chemical corrosion
321	0.08 max	17.0–19.0	8.0–11.0	Ti min, 5 times C	An 18–8 type, stabilized against intergranular corrosion at elevated temperatures.
347	0.08 max	17.0–19.0	9.0–12.0	Cb min, 10 times C	An 18–8 type, stabilized against intergranular corrosion at elevated temperatures.

Table II—Typical Mechanical Properties of Annealed Austenitic Stainless Steels

AISI Type No.	Annealing* Temperature F	Hardness Rockwell B	Tensile Strength psi	Yield Strength (0.2%) psi	Elongation in 2 in. percent	Reduction of Area percent	Izod Impact V-notch ft-lb
302	1,750–2,050	75–84	85,000	30,000	60	70	100–115
303	1,800–2,050	80–90	88,000	33,000	54	60	65– 80
304	1,750–2,050	75–84	85,000	30,000	60	70	100–115
309	1,850–2,050	85–95	95,000	45,000	48	67	100–115
310	1,900–1,950	85–95	95,000	45,000	45	65	100–115
316	1,850–2,050	75–85	85,000	30,000	60	70	95–110
321	1,700–1,950	75–85	85,000	30,000	55	70	95–110
347	1,700–2,000	75–85	87,000	32,000	50	70	95–110

* Time at annealing temperature 10 to 30 min. Although steels can be air cooled from annealing temperature, water quenching insures the retention of carbides in solid solution. This is usually desirable.

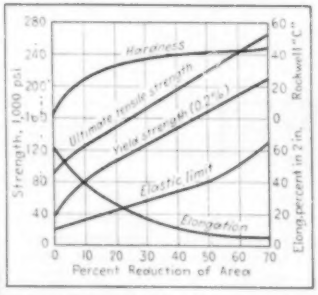
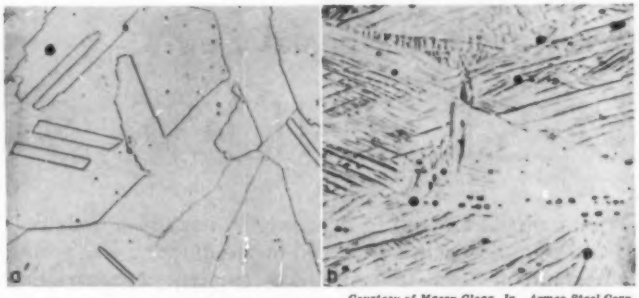


Fig. 1—Effect of cold work, expressed as percent reduction of area, on the mechanical properties of types 302 and 304.



Courtesy of Mason Clogg, Jr., Armco Steel Corp.

Fig. 2—Effect of cold work on microstructure of type 304 stainless steel (x500): (a) Fully annealed, structure consists of austenite showing annealing twins; (b) cold worked, 40 percent reduction of area. Note numerous slip lines in individual grains.

be welded, brazed, or soldered. Their toughness makes machining of all but the free-machining variety difficult.

All of these steels can be annealed by heating to about 1,800-2,000 F. The method of cooling is not critical, except where carbide precipitation is undesirable; in such applications, rapid cooling (quenching) from the annealing temperature is necessary. Maximum softness and workability are obtained when steels are annealed at the higher temperature, but for some applications this is undesirable since some grain coarsening occurs. Table II indicates annealing temperature ranges of the austenitic stainless steels and resultant mechanical properties.

As a group, the austenitic stainless steels are the most corrosion resistant of all the stainless steels—and also the most expensive. They have excellent resistance to acetic, nitric, and citric acids, foodstuffs, sterilizing solutions, most of the organic chemicals and dyestuffs, and a wide variety of inorganic chemicals. Typical applications are for outdoor trim, kitchen equipment, dairy utensils, soda fountains, and lightweight transportation such as aircraft.

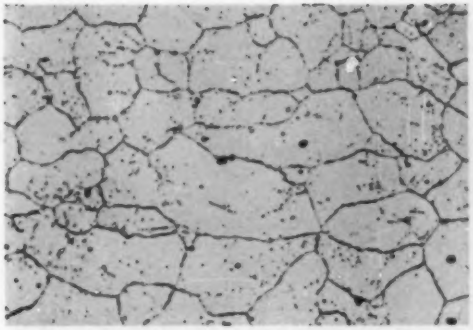


Fig. 3—Network structure formed by chromium carbides precipitated at the grain boundaries in type 304 stainless steel sensitized 2 hr at 1,200 F (x500). Etched electrolytically in a 10 percent solution sodium cyanide. Type 302 shows similar effect.

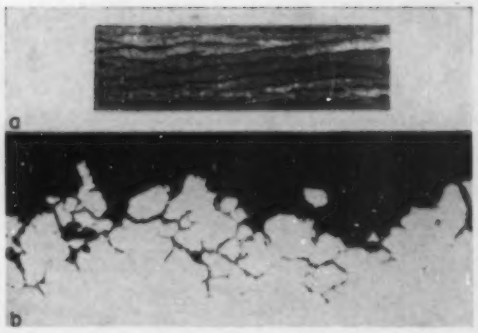
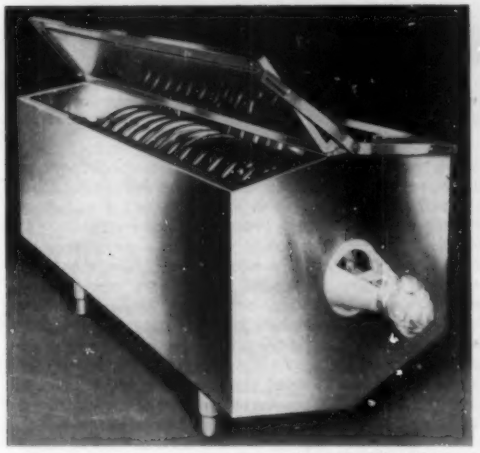
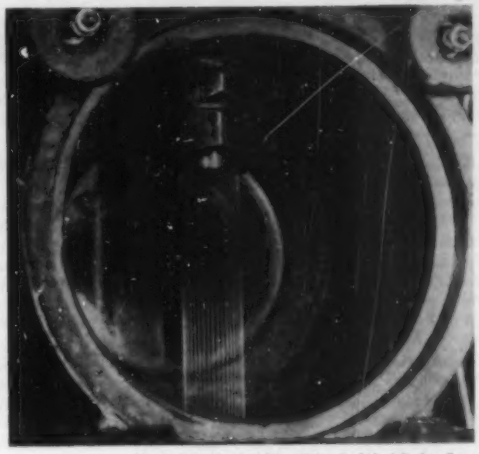


Fig. 4—Intergranular embrittlement of 18-8: (a) Sample embrittled in laboratory and then subjected to simple bend test (x3). Note deep cracking; (b) microstructure of a portion of a failed type 302 aircraft exhaust collector ring (unetched, x100).



International Nickel Company

Fig. 5—Coil vat for heating and cooling liquid dairy products has type 302 stainless steel coils, body and sanitary seals. Coils made of welded stainless steel tubing are efficient and sanitary.



Electro Metallurgical Div., Union Carbide & Carbon Corp.

Fig. 6—Silk-like synthetic fiber, Vinyon N, is made by extruding liquid "dope" through stainless steel spinnerette and solidifying in stream of hot air. Spinnerettes are made of types 304 or 316.

TYPES 302 AND 304. Popularly known as 18-8, these types are similar except in carbon content, the former containing 0.08 to 0.20 percent carbon and the latter containing 0.08 percent maximum carbon. Because of the higher allowable carbon content, type 302 is the cheaper of the two grades. It is also somewhat stronger and the austenitic structure is more stable, since carbon, like nickel, tends to stabilize austenite. These steels are frequently used in the cold-worked condition. The marked improvement effected in mechanical properties by cold working is shown in Fig. 1; Fig. 2 shows the effect on the microstructure.

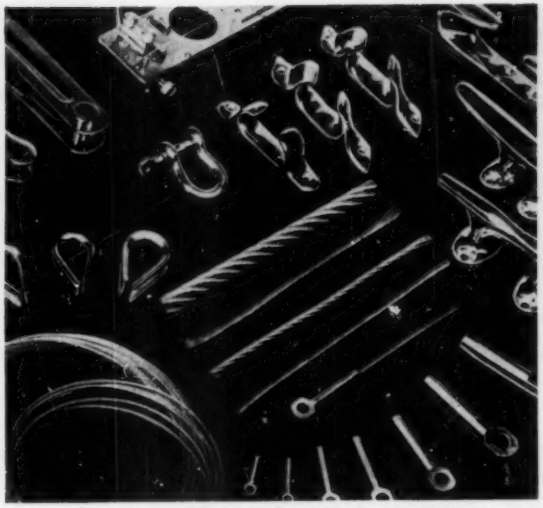
Both of these steels precipitate chromium carbide at the grain boundaries (Fig. 3) if maintained in the temperature range 800 to 1,400 F for any length of time. This is not deleterious unless the steel is either simultaneously or subsequently exposed to acidified corrosive conditions, causing intergranular corrosion. When this occurs, the steels lose their metallic ring and become quite brittle. The type 302 steel, with its higher carbon content, is more susceptible to intergranular corrosion (Fig. 4) than the lower carbon type 304. In either steel, the precipitated carbides can be redissolved by annealing. Fig. 5 shows a typical application of type 302 stainless.

If fabrication involves much machining, the free machining type 303 stainless should be used.

TYPES 309 AND 310. These two stainless steels contain considerably more alloy content than the 18-8 types, and are superior to 18-8 in corrosion resistance. They are used for high temperature applications such as furnace parts, oven linings, still tube supports.

TYPE 316. This is a modification of 18-8, made by the addition of 2 to 3 percent molybdenum. Since molybdenum is a ferrite-forming element (similar to chromium in this respect), the nickel content is increased to maintain the austenitic structure.

This stainless steel has the greatest corrosion resistance of any of the 18-8 types and is particularly suited for applications involving severe corrosion, especially the "pitting" type of cor-



Electro Metallurgical Div., Union Carbide & Carbon Corp.

Fig. 7—Marine hardware of 24-12 stainless (type 309) resists salt water corrosion and retains longtime strength. Types 304 and 316 are also used.

International Nickel Company

Fig. 8—Fabricated of 19-9 stainless, exhaust of B-50 is light in weight and resistant to high temperatures.

rosion. Fig. 9 shows the improvement in mechanical properties effected by cold working.

TYPES 321 AND 347. These two steels are modifications of the 18-8 analysis developed to resist intergranular corrosion or intergranular embrittlement. All of the austenitic stainless steels except types 321 and 347 are susceptible to intergranular embrittlement after certain treatments.

These steels are made with minimum amounts of either titanium or columbium, depending on the carbon content; these elements combine with carbon, inhibiting the precipitation of chromium carbides. The type 321 steel (containing titanium) costs appreciably more than the ordinary 18-8 type and the type 347 steel containing columbium is even more expensive. The resistance to intergranular embrittlement of the titanium-bearing steel (type 321) is generally enhanced by a stabilizing heat treatment consisting of a 1 to 2 hr anneal at 1,600 F. This treatment is not necessary for the columbium-bearing steel.

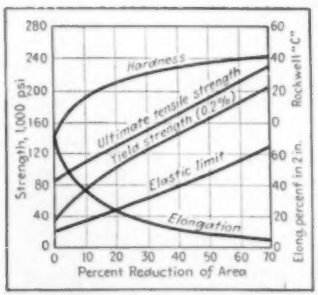


Fig. 9—Effect of cold work, expressed as percent reduction of area, on the mechanical properties of type 316 stainless steel.

Users of the 18-8 steels frequently worry unduly about the "bugaboo" of intergranular embrittlement and may use types 321 or 347 stainless where types 302 or 304 would be entirely satisfactory. The following points should be considered:

1. If the proposed application involves exposure in the temperature range 800-1,400 F and to acidic environments, use of type 321 or 347 is indicated.

2. If the same temperature conditions exist, but the corrosive atmosphere is air or other gases that are definitely non-acidic, ordinary 18-8 can be used. The exhaust gases of internal combustion engines call for the use of type 321 or 347 in aircraft exhaust collector rings and stacks.

3. If the proposed application involves exposure only to atmospheric or slightly elevated temperatures (up to about 750 F) then the type 321 or 347 steel is not necessary provided the steel was not exposed to the temperature range 800 to 1,400 F during fabrication. If it was, the following facts should govern selection.

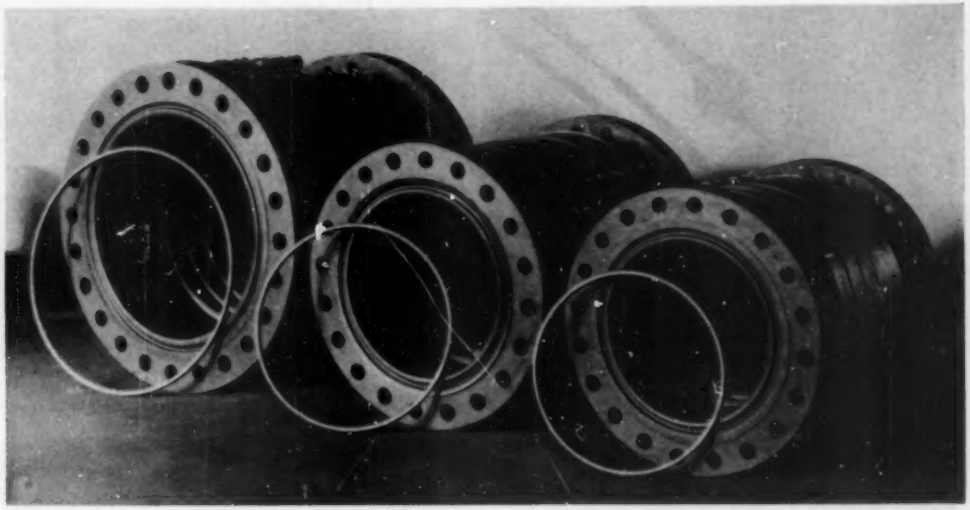
4. If the proposed application involves exposure to atmospheric corrosion or even to acidic corrosive solutions but at room temperature, type 321 or 347 is not needed. If the material is to be used under hot acidic corrosive conditions, type 321 or 347 should be used unless the steel is annealed subsequent to fabrication.

Welded joints have certain heat-affected areas caused by heating in the sensitizing temperature range (800-1,400 F). The harmful precipitation of carbides in the 18-8 steels is a function of time and temperature, and is also affected by the amount of carbon. If the heat effect of welding is dissipated rapidly, such as in shot welding thin sheet, even the high carbon type 302 may not be adversely affected. Because of its lower carbon content, type 304 can be used with greater latitude. If the heat of welding cannot be dissipated rapidly enough to prevent precipitation of carbides, but the structure is annealed subsequent to welding and cooled rapidly, then ordinary 18-8 can be used. However, if susceptibility to intergranular corrosion is not important, no such precautions are necessary.

Table III gives a qualitative summation of some general properties of all the stainless steels in general use.

Special Steels and Treatments

The fact that the austenitic stainless steels can be hardened only by cold working has somewhat limited their application. A special stainless steel (U.S.S. Stainless W) is amenable to age hardening. This steel has a nominal composition of about 0.07



Electro Metallurgical Div., Union Carbide & Carbon Corp.

Fig. 10—Stainless steel expansion joints are built of type 347 (containing columbium) to withstand high pressures and temperatures. Joints of this type are used in oil refining equipment and similar applications. Type 347 resists intergranular corrosion.

percent C, 17 percent Cr, 7 percent Ni, 0.70 percent Ti, and 0.20 percent A1. It is quite soft and ductile when annealed at about 1,850-1,950 F and the rate of cooling is immaterial. Aging at 950 F gives maximum tensile and yield strength, but lowest impact and ductility. The highest aging temperature, 1,050 F, improves ductility and impact at some sacrifice of the yield and tensile strength. Rapid cooling after aging improves the impact resistance which, however, is quite low as compared with the 18.8 steels. The maximum properties obtainable are about 225,000 psi tensile, 200,000 psi yield, and C 45 hardness.

Stainless steels have generally poor resistance to sulphuric acid, but a material (Carpenter Stainless No. 20) has been developed which has improved resistance to this acid. Its nominal composition is 0.07 percent max C, 1 percent Si, 20 percent Cr, 29 percent Ni, 2 percent min Mo, and 3 percent min Cu. Water quenching after heating uniformly to 2,100 F is necessary for maximum corrosion resistance. This steel is susceptible to intergranular embrittlement and welded structures should be annealed. However, this heat treatment is not necessary for shot welded structures.

The austenitic stainless steels can be surface hardened by nitriding, which is advantageous when a wear-resisting surface is necessary.

The use of stainless-clad steels should not be overlooked by manufacturers as a means of securing corrosion resistance at a lower material cost.

Scale formed during heat treatment can be removed by various pickling procedures, or, if a smooth surface is not necessary, by sand blasting. A passivating treatment should be given as a finishing treatment to all stainless steels which have been fabricated or otherwise handled, even though they appear clean. The objective thus accomplished is the removal of contaminating iron particles and other foreign substances which frequently act as foci for localized corrosion.

Stainless steel with a fairly high degree of surface finish is desirable for many applications but the polished surfaces of stainless sheet can easily be ruined during forming operations. Sheets so finished can be purchased with a protective peelable plastic film. This coating protects the surface during forming and handling and can be left on the finished article to be removed by the ultimate consumer. If polishing by the fabricator is necessary, this may be done either mechanically or electrolytically. The latter is particularly well suited for irregularly shaped articles.

Stainless steels can be colored, to obtain decorative architectural effects.

Table III—Comparison of Fabricating and Forming Qualities of Stainless Steels

Property	Martensitic						Ferritic				Austenitic							
	410	416	420	420F	440A	440C	430	430F	442	446	302	303	304	309	310	316	321	347
Welding	Good if Annealed	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Fair	Fair	Good	Poor	Good	Good	Good	Good	Very Good	Very Good
Machining	Good	Very Good	Fair	Good	Fair	Fair	Fair	Good	Fair	Fair	Poor	Good	Poor	Poor	Poor	Poor	Poor	Poor
Cold Forming	Good	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Poor	Very Good	Fair	Very Good	Good	Good	Very Good	Very Good	Very Good
Approx. scaling temp., F. (Cont. Serv.)	1,200	1,200	1,200	1,200	1,200	1,200	1,500	1,500	1,700	2,000	1,600	1,600	1,600	2,000	2,100	1,600	1,600	1,600

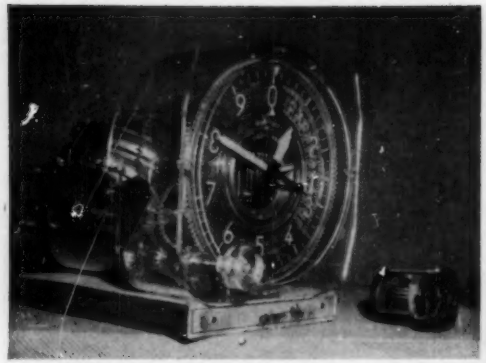
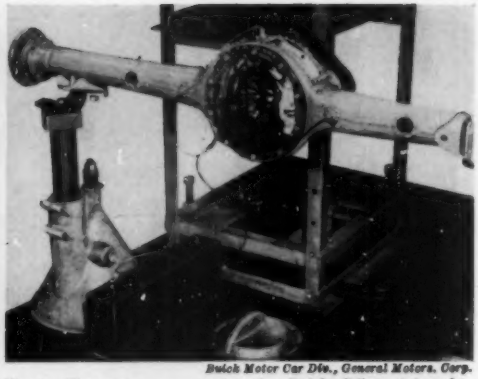


Fig. 1—Instruction model of aircraft altimeter. Scale is 4 to 1. Plastic parts include dial, protecting cover, indicators and gears.

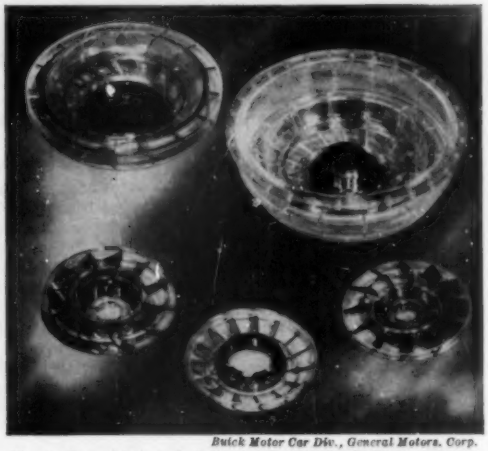


Buick Motor Car Div., General Motors Corp.

Fig. 2—Transparent cover plate for Buick differential makes possible a study of lubricant distribution in differential gears.

National Cash Register Co.

Fig. 3—Transparent housing for a special model National industrial accounting machine permits observation of working parts.



Buick Motor Car Div., General Motors Corp.

Fig. 4—Parts fabricated of plastic material for Buick Dyna-Flow transmission model. Some parts are fabricated of dyed material.

Transparent Working Models

WORKING MODELS of machines and mechanisms with parts made of transparent plastics are helping designers to build improved products. With such models, designers can see the operation of working elements that are ordinarily covered and hidden by the frames and housings of the actual machine. These models can also be used for exhibition and demonstration purposes, and to teach engineers how a complicated mechanism operates.

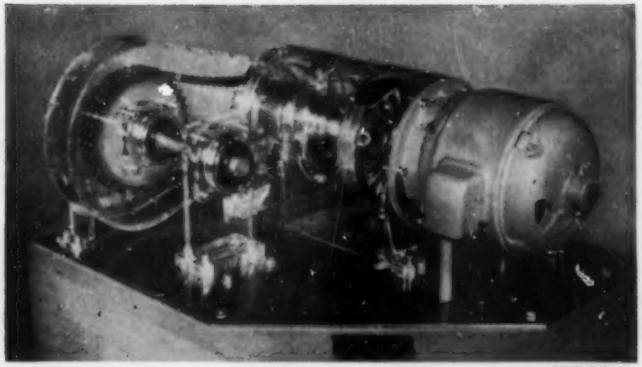
Detailed studies have been made of switch linkages and contacts in motion by observing their action through housings of transparent plastics. Transparent tubing and cover plates on valves have advanced the analysis of the flow of lubricants and hydraulic fluids through passages.

During the war, transparent models were used by the military services to teach and demonstrate the operation of altimeters and other instruments. Plastic models of machinery components as complicated as carburetors were made for this purpose.

Many of these transparent working models were expensive to make because costly dies and forming tools were deemed to be necessary. The obvious value of transparent working models, however, impelled the development of special fabricating and forming methods that did not require expensive dies or complicated tooling.

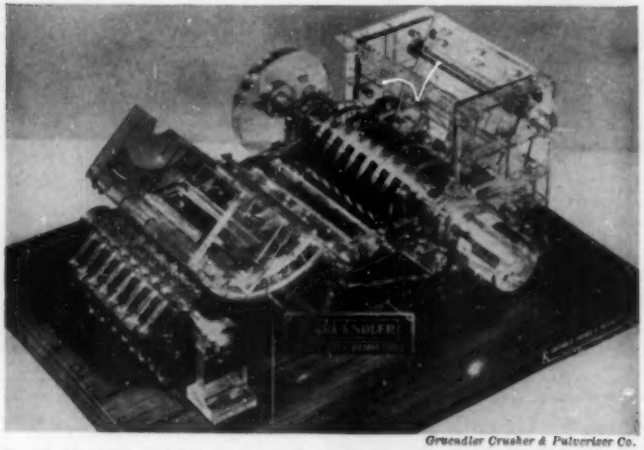
Insignificant changes in original designs often make a considerable reduction in cost possible, even though the transparent plastic part is made to the same production tolerances as apply to the machined metal part being reproduced. Hundreds of machined parts have been produced at a reasonable cost that operate to the same degree of accuracy in the working models as in the original machine.

The transparent plastic model of an altimeter shown in Fig. 1 is made on a scale of four to one. These models



Link-Belt Co.

Fig. 5—Exhibition model of a Link-Belt Electrofluid motorized hydraulic drive. An operator can start and stop this working model by simply pressing push button control.



Gruendler Crusher & Pulverizer Co.

Fig. 6—Small scale working model of a Gruendler heavy duty hammermill for exhibition. All parts of this plastic demonstration model are built exactly to one-eighth scale.

For Design Studies

were used for military instruction. They enable the instructor to point out to the student all the details of the operation of the inner mechanisms. As can be seen in the illustration, all of the parts with the exception of a few small pinions and the metal bellows are made of transparent plastic. With the exception of the bellows, which is operated by an external knob to simulate changes in atmospheric pressure to operate the hands, every little detail of the whole mechanism is visible.

Numerous transparent full scale complete working models or elements of mechanisms have been designed and built to enable engineers to observe and study operations that are hidden from view in the machine. Gears, bearing retainers, flywheels, connecting rods, and similar machined elements can be made from the transparent plastic to obtain a clear unobstructed view. In Fig. 2 is shown a Buick rear end differential with a transparent plastic housing cover attached. Dimensionally, this transparent cover is exactly the same as the steel cover plate used, which can be seen in the lower center of the illustration of the test set up. The engineers can see the flow of lubricant through the differential.

Another application of the use of transparent plastic models to enable observation of working parts is shown in Fig. 3. The machine is a special model prepared for business shows. By making the housing covering the working parts out of clear plastic, the engineers of the National Cash Register Company were able to demonstrate visually the operation of the mechanisms.

Transparent plastic parts were used in a model Buick Dyna-Flow torque converter, Fig. 4. Different colored vanes were used for each rotating element to increase clarity while in motion. These parts are made with the same manufacturing tolerances as the standard metal pieces, and when assembled with the other elements make a transparent working model. This model will be used primarily for exhibition purposes, but it will also serve to clarify to the design engineers some of the details relative to fluid flow, turbulence and other factors.

The advantages of transparent plastic models for exhibition purposes, of course, are well known. In Fig. 5 is shown a transparent working model of the Link-Belt Electrofluid motorized hydraulic drive.

For large size machines, models for exhibition purposes can be made to scale. The Gruendler heavy duty hammermill, shown in Fig. 6; is a striking example of such a working model built to one-eighth scale.

Properly designed transparent plastic models are strong and durable. The acrylic plastic material has an average tensile strength of about 8,000 psi at about 77 F and 3,500 psi at about 100 F. Parts that are not heavily stressed can be used safely at temperatures up to 140 F. This property permits the material to be used as cover plates of housings in which hot lubricant may splash against the material. The optical properties of the plastics are not affected by most lubricants, the material is weather proof, easy to clean, and scratches are easily removed by buffing.

Although where the quantity of pieces is high enough so that parts can be molded more economically, there are sometimes advantages in machining the parts out of stock. Machining has a decided advantage over molding when several colors are desired in one part to emphasize particular features. In the reproduction of the Buick Dyna-Flow, some parts were fabricated from dyed material.

Acknowledgment: PRODUCT ENGINEERING appreciates the assistance and cooperation of the Carleton R. Elliott Company of Dayton, Ohio, in providing information and data from which this article was prepared.

Kinematics of Intermittent Mechanisms
IV—The Three-Gear Drive

S. RAPPAPORT
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MECHANISMS dealt with in the previous articles (see "Kinematics of the External Geneva Wheel", PRODUCT ENGINEERING, July 1949; "The Internal Geneva Wheel", Aug. 1949; "The Spherical Geneva Wheel", Oct. 1949) all have dwell periods of a fixed length, the minimum of which is 60 deg of the cycle for the 3-slot internal Geneva wheel. It is sometimes desirable, however, to have a still shorter dwell period. There are designs where even a momentary stop, theoretically one point but practically a few degrees, is necessary. Such a movement has the additional advantage of a low acceleration in the motion period. This results in a smooth acting mechanism, requiring only small forces. One of the devices for achieving this effect is the "Three-Gear" drive, shown in Fig. 1. It is not well known, but it merits wider application because of its simplicity, flexibility and efficiency.

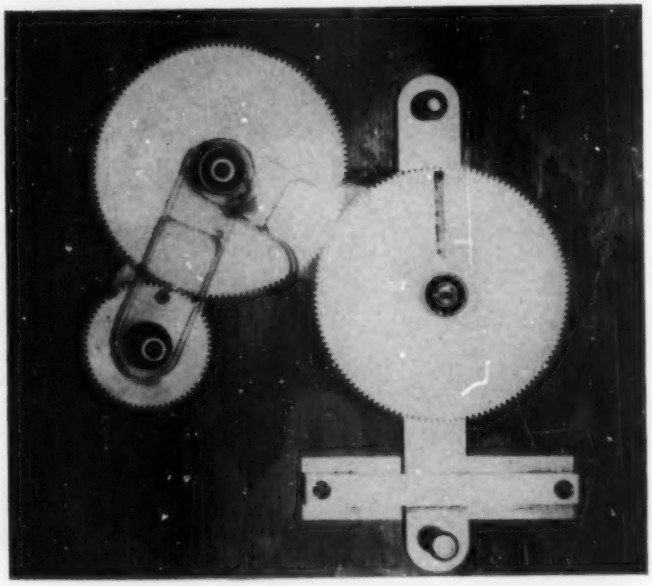


Fig. 1—The "three-gear" drive, an intermittent motion device giving dwell period of only a few degrees. Standard gear forms can be used.

Drive Construction

The driver of the three-gear drive, see Fig. 2, consists of a spur gear mounted eccentrically on the drive shaft at point A. This gear is fixed to the drive shaft so that it cannot rotate on the shaft. Point A on the gear is at the distance a from the center of the gear. Thus, while operating, the gear revolves around A and its center describes a circle of radius, as shown in the drawing.

The driven gear is concentrically mounted on the output shaft at F, and it is fixed rigidly so that it rotates with this shaft.

Motion of the driver is transmitted to the driven gear by an idler held in mesh with both driver and driven gear by two links. These links carry, on their ends, appropriate bearings for the respective centers of the gears.

Driven gear and driver can, of course, be made in any ratio n. The schematic sketch in Fig. 2 is drawn for $n = 1$, whereas the drive shown in Fig. 1 has $n = 2$ as ratio. Therefore n also is the number of momentary stops during one complete turn of the driven gear, since one complete turn of the driver always produces one stop of the driven gear.

Constant rotation of the input shaft, at A, creates two actions: (1) a rotation of the idler gear around its center, which is caused by the rotation of the driver, and (2) an oscillating motion of the idler center around F, which results from rotation of the center of the driver around A. These two motions alternately add to and subtract from each other's movement. This action causes the driven gear to move with variable speed, and to come to a stop, during the subtracting phase. The pause occurs at the moment the rotary and oscillating motion are of the same magnitude, thus cancelling each other. This condition happens when points A, P and Q fall on a straight line.

The apparent dwell period, though theoretically only one point, approaches in practice about 45 deg of the cycle, if the eccentricity a is appropriately chosen. A small a keeps the apparent dwell period short; increasing values of a increase the apparent dwell period.

The practical limits of a lie between $0.38r$ and $0.87r$, where r is the pitch radius of the driver. Experience shows that about $0.8r$ gives a dwell period of practically 45 degrees.

Once a is chosen, the center distance b has to be calculated. See Fig. 3 for the working sketch. Starting from the previously mentioned condition that points A, P and Q lie in a straight line:

$$AP = \sqrt{r^2 - a^2} \tag{1}$$

$$PQ = \frac{2R}{r}\sqrt{r^2 - a^2} \tag{2}$$

$$QT = n\sqrt{r^2 - a^2} \tag{3}$$

$$PT = na \tag{4}$$

From

$$b = \sqrt{AT^2 + FT^2}$$

it follows that the center distance is

$$b = \sqrt{[r^2 - a^2]\left[\frac{2R}{r} + n + 1\right]^2 + a^2n^2} \quad (5)$$

If this center distance is used, the output shaft will come to a momentary stop at some position. However, a decrease of b causes the output shaft to slow down without coming to an actual stop; whereas an increase of b has the result that the output shaft reverses its rotation for a short interval, after which it resumes its original direction of rotation.

To prevent interference between driver and driven gear in their closest position to each other and to maintain a minimum clearance e between them, (see Fig. 2) the pitch radius R of the idler is found from

$$R \geq \frac{r}{2}\left[\sqrt{\frac{[r(n+1) + a + e + 2f]^2 - a^2n^2}{r^2 - a^2}} - n - 1\right] \quad (6)$$

where f is the addendum of the gears.

It is not feasible to describe the displacement, velocity and acceleration curves of this drive in workable equations of analytical geometry. The formulas become too involved and unwieldy. However, these curves can be plotted comparatively easily by a graphical method.

The displacement curve, Fig. 4, is found in the well-known conventional manner. This chart, as well as Figs. 5, 6 and 7, are based upon a mechanism in which $n = 1$, $r = 1$, $a = 0.8r$, $e = 0.25$ and $f = 0.032$.

The velocity curve, Fig. 5, can be found either by graphical differentiation of the displacement curve or by using the method of instantaneous centers (Kennedy's Theorem). The latter is preferable because of greater accuracy.

A step by step description of this method follows, and Fig. 6 shows the operations.

1. Draw, preferably in enlarged scale, points A and F at distance b.

2. Draw a circle with radius a and center A (henceforth called: circle A).

3. Draw a circle with radius nr and center F (henceforth called: circle F).

4. Divide the periphery of circle A into equal parts (in this example, 60) and number the points thus found.

5. Draw an arc with radius c where $c = R + nr$, and center F (henceforth called arc C).

6. Strike arcs with d as radius, where $d = r + R$, and consecutive numbered points on circle A as centers. Extend arcs to intersect with arc C.

7. Number the points thus found correspondingly. The construction is shown on Figs. 4, 5, 6 and 7 for point No. 21.

8. Connect points of equal number on circle A and arc C. This connecting line is d.

9. Draw radii from numbered points on arc C to F and number their intersections with circle F correspondingly.

10. Cut r off d and connect the point thus found with point of same number on circle F.

11. Extend this connecting line until it intersects with the extension of a line drawn through points A and F. The points thus found are the common

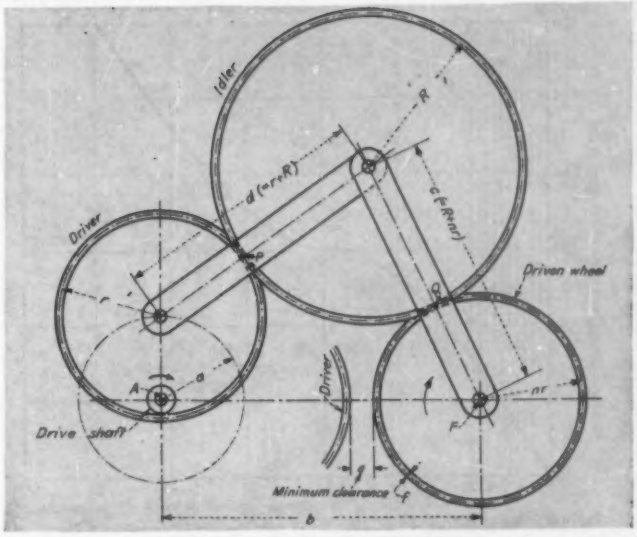


Fig. 2—Schematic arrangement of the three-gear drive showing the nomenclature. Both the driver and the driven gears are fixed rigidly to input and output shafts at points A and F respectively. This arrangement is based on the following data: $n = 1$, $r = 1$, $a = 0.8$, $r = 0.8$, $e = 0.25$, $f = 0.032$. Then $R = 1.5$ and $b = 3.105$, in the same units as r, the driver radius.

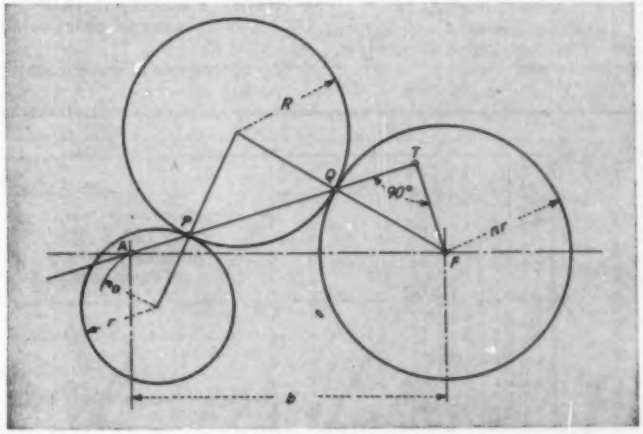


Fig. 3—A working sketch for determining the center distance b. A, P and Q must lie on a straight line for this calculation. Point T has no physical significance.

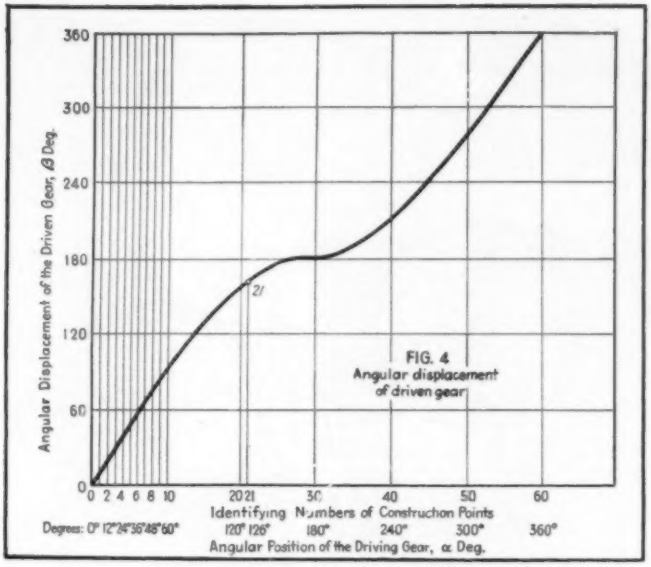


FIG. 4
Angular displacement of driven gear

instantaneous centers of rotation, or centros, of the circles A and F.

12. Draw $MN = \omega$, representing the constant angular velocity of the driver in radians per second.

13. Connect points A and N by a line (henceforth called H) and extend it on both sides.

14. Draw verticals from the centros and intersect with H.

15. Number the points thus found correspondingly.

16. Draw a vertical through K.

17. Connect numbered points on H with point F.

The intersections of these connecting lines with the vertical through K give the angular velocities ψ of the driven gear. Plotting the consecutive values of ψ against the corresponding α, Fig. 5, results in the velocity curve shown.

It can be seen from the graph that the curve is shallow, almost flat, in the region where $\psi = 0$. Analytically expressed, the tangent has more than two points in common with the curve in that place. This property of the velocity curve accounts for the fact that the apparent dwell seems to extend over several degrees, up to about 45 deg as pointed out earlier in the discussion.

To find the acceleration curve, Fig. 7, use graphical differentiation of the velocity curve, and proceed as follows:

1. Draw, in Fig. 5, point R in the distance of one radian from the zero point.

2. Draw tangents to the numbered points on the velocity curve.

3. Draw lines through point R parallel to these tangents.

The intersections of these lines with the ordinate axis are the angular accelerations γ of the driven gear, and are plotted for the Fig. 7 curve.

In conclusion, it should also be noted that the curves are not symmetrical. This is for the same reason that causes the motion curves of a crank drive to deviate from the laws of a simple harmonic motion.

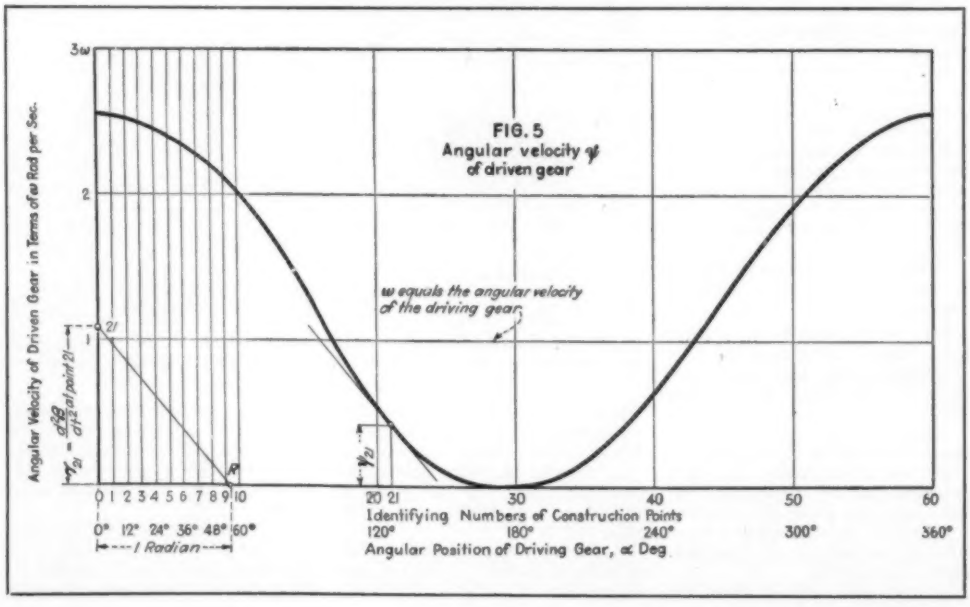


FIG. 5
Angular velocity ψ of driven gear

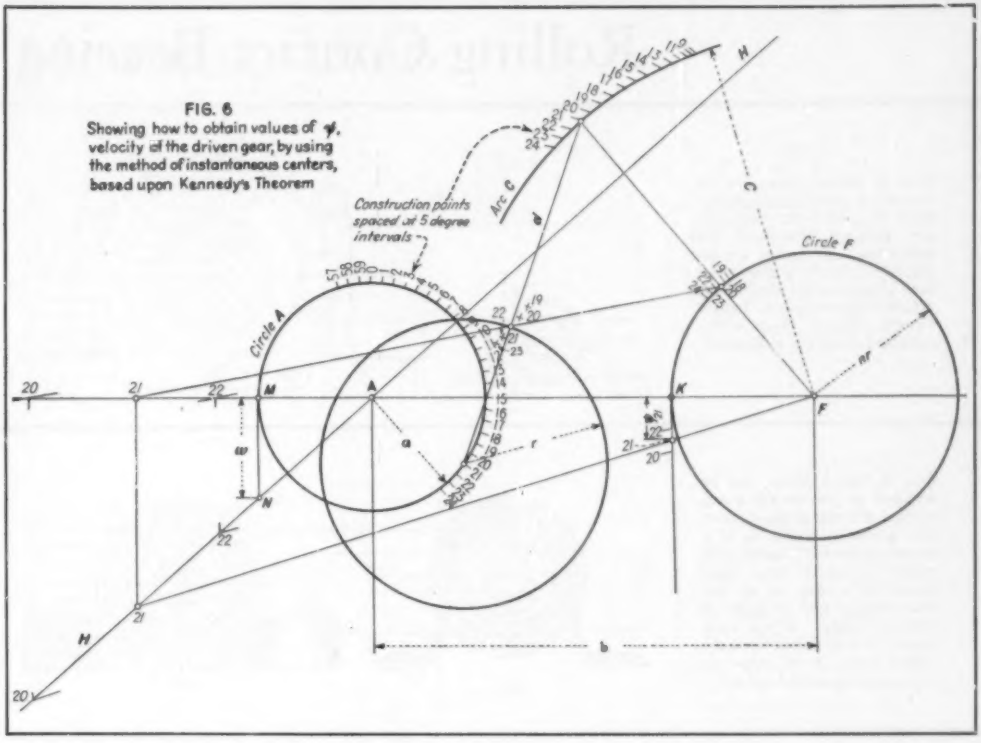


FIG. 6
Showing how to obtain values of v, velocity of the driven gear, by using the method of instantaneous centers, based upon Kennedy's Theorem

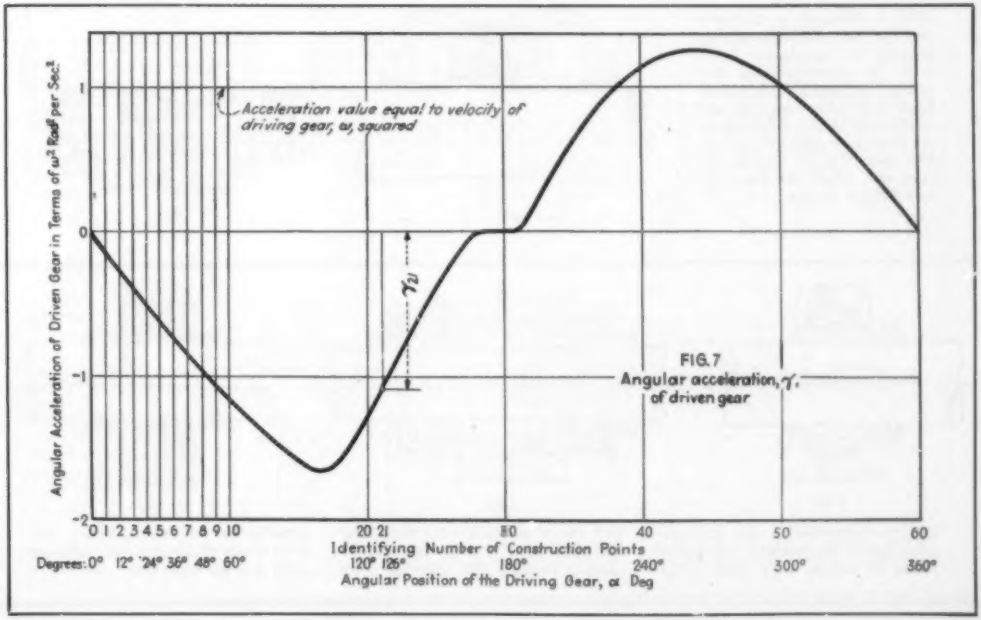

Angular Acceleration of Driven Gear in Terms of ω² Rad per Sec²
Acceleration value equal to velocity of driving gear, ω, squared
γ21
1
0
-1
-2
0 1 2 3 4 5 6 7 8 9 10 20 21 30 40 50 60
Identifying Number of Construction Points
Degrees: 0° 12° 24° 36° 48° 60° 120° 126° 180° 240° 300° 360°
Angular Position of the Driving Gear, α Deg

FIG. 7
Angular acceleration, γ, of driven gear

Rolling Contact Bearing

FIG. 1—Pillow blocks are for supporting shafts running parallel to the surface on which they are mounted. Provision for lubrication and sealing are incorporated in the pillow block unit. Assembly and disassembly are easily accomplished. For extremely precise installations, mounting units are inadvisable.

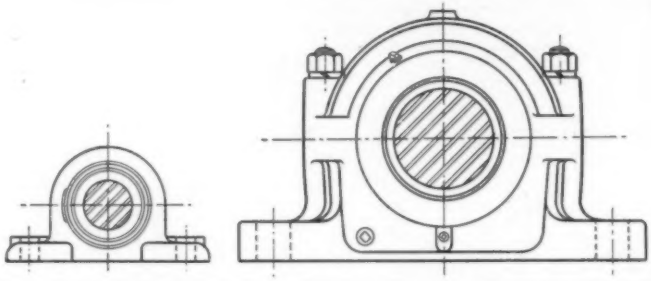


FIG. 2—Pillow blocks can be designed to prevent the transmission of noise to the support. One design (A) consists of a bearing mounted in rubber. The rubber in turn is firmly supported by a steel casing. Another design (B) is made of synthetic rubber. Where extra rigidity is required the synthetic rubber mount can be reinforced by a steel strap bolted around it.

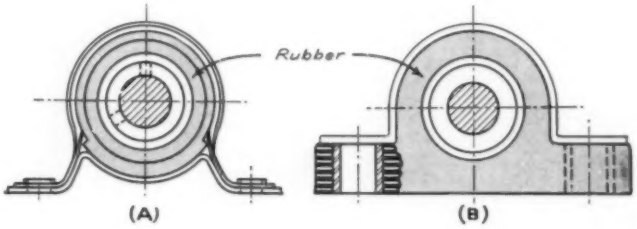
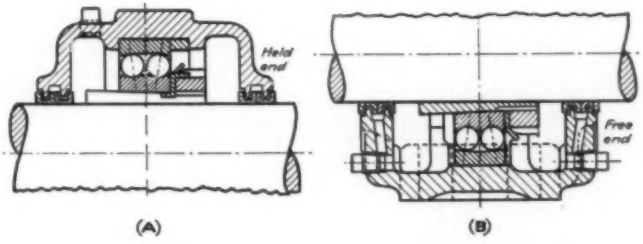


FIG. 3—Changes in the temperature are accompanied by changes in the length of a shaft. To compensate for this change in length, the pillow block (B) supporting one end of the shaft is designed to allow the bearing to shift its position. The pillow block (A) at the other end should not allow for longitudinal motion.



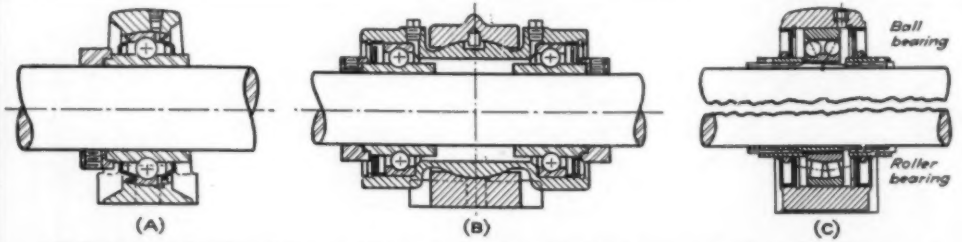


Fig. 4—Compensation for misalignment can be incorporated into pillow blocks in various ways. One design (A) uses a spherical outer surface of the outer race. Design (B) uses a two-part housing. The spherical joint compensates for misalignment. Another design (C) uses a spherical inner surface of the outer race.

Mounting Units

Fig. 5—The cylindrical cartridge is readily adaptable to various types of machinery. It is fitted as a unit into a straight bored housing with a push fit. A shoulder in the housing is desirable but not essential. The advantages of a predesigned and preassembled unit found in pillow blocks also apply here.

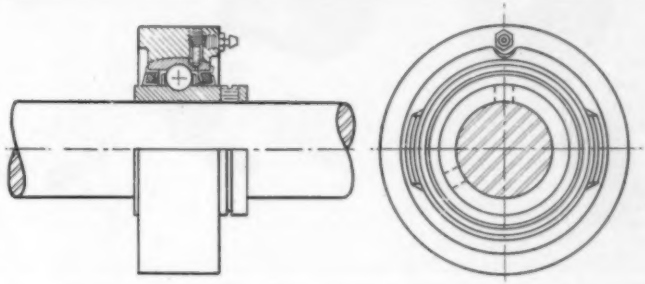


FIG. 6—The flange mounting unit is normally used when the machine frame is perpendicular to the shaft. The flange mounting unit can be assembled without performing the special boring operations required in the case of the cartridge. The unit is simply bolted into the housing when it is being installed.

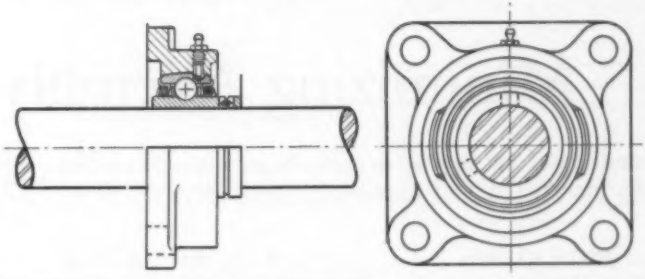
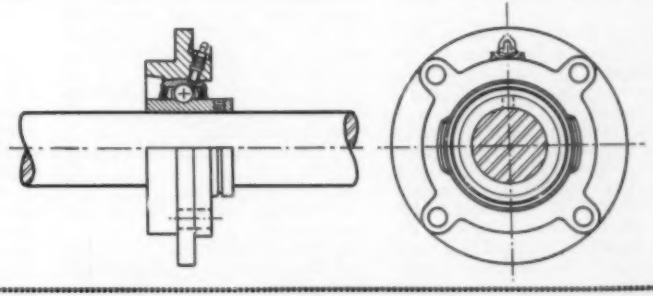


FIG. 7—The flange cartridge unit projects into the housing and is bolted in place through the flange. The projection into the housing absorbs a large part of the bearing loads. A further use of the cylindrical surface is the location of the mounting unit relative to the housing.



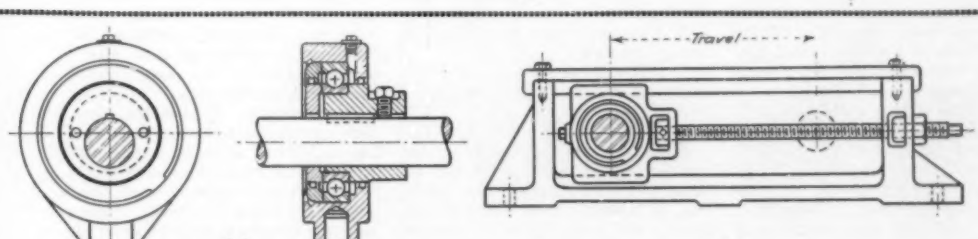


FIG. 8—Among specialized types of mounting units are (A) Eccentrics used particularly for cottonseed oil machinery and mechanical shakers and (B) Take-up units which make possible an adjustment in the position of the shaft for conveyor units. Many other types of special rolling contact bearing mounting units are made.

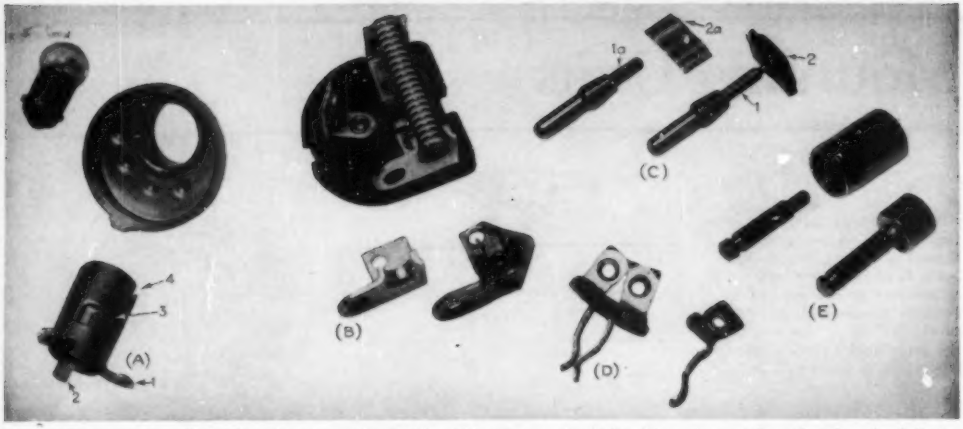


Fig. 1—Five examples of multifunction parts. Lampholder (A) supports the bulb, drives the switch and makes the indexing click. Switch terminal (B) is shown in old three-piece and new one-piece designs. Other parts are described in the text.

Minimizing Assembly Costs

Seven principles that, applied to parts design, will aid in reducing the time and cost of assembling mechanical components.

ERWIN RAUSCH
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DESIGNERS SEARCHING FOR PRODUCT ECONOMY usually have many avenues to explore. By effecting material economies, by ingenious tooling, and by designing parts that are easy to form or machine, important savings can be realized. But there is a growing appreciation that, for many kinds of products ranging from million-dollar aircraft to household appliances, the biggest manufacturing expense is the cost of assembling. And it is ironical that the better the job the designer does in reducing the amount of material and the fabrication expense in a product, the bigger the assembly cost will be in proportion to the total cost.

Extensive savings are available by designing with an eye to simplified assembly. Particularly is this true with small, mass-produced mechanical units. A systematic approach to this design objective may be warranted, and the following suggestions should be helpful.

The chief objective for the designer to keep in mind, from the standpoint of economical assembly, is to eliminate every possible need for decision on the part of assembly personnel. Mental processes invite errors, as well as consume time. No matter how trivial these errors and time losses may be, if neglected, their aggregate will add up to unbelievably high production costs.

Here are seven principles that can be applied to create products of maximum "assemblability."

1. Use the smallest possible number of parts.
2. Standardize parts.
3. Maintain ample clearances for loose assembly.
4. Use sub-assemblies.
5. Design parts of optimum size for handling.
6. Eliminate every possibility of wrong assembly.
7. Relate the design to the assembly method

Least Number of Parts

The fewer parts included in a given product, the shorter will be the assembly operation, since the reduction in assembly time varies almost directly with a decrease in the number of component parts. With fewer parts, tooling costs are lower. Less area is required for the production line, and fewer parts have to be produced, purchased, stocked.

After the first preliminary sketches have been made, the designer should analyze each component part of his product with the following questions in mind:

1. Is this part necessary? What would happen if it were eliminated altogether?
2. Could the functions of this part be absorbed by any one of the adjacent parts?
3. Could this part be altered so that it will also take on the job of another part?

Often an eyelet or a rivet can be eliminated by extruding one of the metal parts to be fastened. Reinforcing bends and grooves can supplant separate supports. And notches, tabs, grooves for holding and other staking arrangements can be incorporated into parts made of sheet metal, tubing and bar stock. Eighteen such ideas were illustrated by sketches in PRODUCT ENGINEERING, May 1949, p 122, 123, "Joining Sheet Metal Parts Without Fasteners."

Five examples of parts that perform several functions are shown in Fig. 1. Noteworthy is the lampholder because it represents the idea of combining parts in its general sense. This lampholder, since its initial design, had two functions: (1) It drove a switch mechanism with two lugs on the lower end, connection with the knob being provided by a groove at the top; (2) It supported the bulb. A clickspring also was staked onto

the lampholder. This spring produced indexing snaps in conjunction with the switch housing, as the switch was operated. When it became necessary to produce the item at a lower cost, it was discovered that the lampholder could be altered to produce the click. The clicking action is accomplished by the dimple (1) engaging the detents in the housing. Lugs on the bottom end (2) drive the switch, while the holder engages with the knob on the other side of the housing through the slot (4). Finally, the notches (3) support the bulb. Other multifunction parts are shown in Fig. 1. The switch terminal (B) at the right consisted of terminal, fuseclip and eyelet, and it required the eyeletting operation for assembly. At the left is a redesigned part whose function is equivalent to the three-piece assembly. For grasping, use was made of the spring action inherent in the coil-wound resistor unit shown on the complete switchbase assembly above it. (C) When the brass plunger was replaced by a plastic one, it was possible to exchange the three-piece assembly (2) with the simple stamping (2a). (D) The electrical terminal-contact combination at the right usually consists of two parts joined when they are riveted to the stamped plastic plate. By combining the two parts, a shorter, more direct current path was achieved, and with considerable savings. (E) This single part replaces efficiently, the two parts of the older design.

Parts Standardization

The designer should always endeavor to use, in a new product, parts and sub-assemblies that are already being manufactured or purchased for other products. Speaking solely of the assembly line and the production process, these advantages accrue:

1. The operator, being familiar with the part, will know how to hold it. Training time will be eliminated and he will attain his top capacity sooner than he would if the part was completely new.

2. If a sub-assembly can be used in more than one product, the operation of that sub-assembly line can be maintained for longer periods without disruption of operators, and without time losses in the changeover. Fig. 2 illustrates this principle.

3. Materials handling will be simplified since fewer parts bins have to be exchanged when the assembly line is switched to another product.

4. Set up time on eyeletting machines, screwsetting machines, drill presses and riveting machines can be reduced to a minimum if the designer uses the same size of fastener for many different products. Use of the same nut on many different items might make it possible for only one size electric wrench to be kept on the assembly line.

There are savings other than those from the assembly line which reward parts standardization in design. Inventory and storing is simplified; many tools, such as jigs and fixtures which might otherwise stand idle, can be utilized and new ones need not be built; purchase prices or production costs also will be lower because of the larger quantities involved.

Standardization implies more than utilizing the plant's existing designs. It is most important to use standard purchased parts. Manufacturers' standard parts should be used for all fasteners and similar items, since those can be obtained at much lower costs than "specials." Specials require engineering work, blueprints and specifications, and they may delay production since they have to be fabricated to order.

Clearance for Loose Assembly

Tight fits are costly. They waste time and they are also bad for the worker, psychologically and physiologically, because he is irked by the bad fit and also tires more rapidly from the greater physical exertion.

At the writer's firm there have been many occasions where the loosening of fits has produced enormous production increases. In one instance, a steel shell and a brass bushing, which had to be joined by staking, required a distinct push to make the shell to seat on the shoulder against which it was to be staked. Production was less than 100 assemblies per hour; loosening the fit increased output to nearly 800 units per hour.

Another assembly called for metal stampings with three lugs to be inserted into mating plastic stampings for insulation. An error in designing had made one of the slots slightly too small; pliers were required to force the two parts together; production: 250 sets per hour. The die was sent to the toolroom for rebuilding and the next time the item was produced, 1,100 assemblies were finished in the first hour. The gain resulted merely from generous clearances.

It is impossible to give, blindly, an amount of clearance that should be allowed for each of the infinite variety of industrial assemblies. Tolerance limitations in the manufacture of the component parts enter this consideration, as well as the materials, the size of the parts, their shape, and the outline of the mating surfaces.

Sometimes the individual designer is reluctant to rely upon his personal experience when specifying clearances because the great intricacies of shape, delicate alignments, or other extreme circumstances make such empirical decisions hazardous. For such designs, it is advisable to make accurate models and to find, by experimentation, the optimum clearance for the two parts. Incidentally, the amount of clearance thus determined also fixes the tolerances that have to be specified for the contacting sections.

For threaded parts, sufficient clearance can best be achieved by the use of the new Unified Screw Thread Classes, 2A and 2B, which provide an allowance for high cycle wrenching and thus insure against thread seizure. This clearance also permits plating of threads. For detailed analysis of the merits of the new Unified Screw Thread Standard, see PRODUCT ENGINEERING, May 1949, p 81-85, "What the New Screw Thread Standard Means to Designers."

Sharp edges on stamping, burrs on

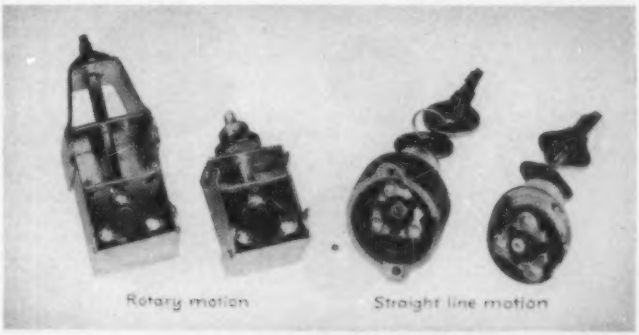

Fig. 2—These four automotive switches all use the same contact plate, even though rotary motion and push-pull motion are needed in different switches.

screw-machine parts, and screws without starting threads are also items that can cause expensive delays on the assembly line, if they have not been considered in advance by the designer. Particularly is this the case with burrs and sharp edges on steel stampings, since such defects are irreparable once a die has been completed.

Use of Subassemblies

If a product cannot be manufactured on a moving table or belt where each operator adds one or more parts before the unit moves on, then it is best to design it so that it can be produced from several subassemblies. Fewer parts and fewer motions are required from the operator for each cycle, and therefore he can gain much greater skill and dexterity. Training time or "warm-up time" is also considerably shorter for such sub-assemblies than it is for more complicated units.

Rythmic, continuous motions with both hands are least tiresome. They can easily be achieved in an assembly composed of four parts or less. With six parts a considerably longer training period is required and inferior workers will have to stop frequently to decide which part to reach for next. Beyond six parts rythmic motions are impossible and production will consequently be impaired.

Materials handling also enters into this consideration. It is relatively easy, with the aid of hopper bins, to bring within easy reach of the operator's hands several hours' supply of up to four, five, or even six different parts. But a larger number of parts, however, can only be so arranged if the parts are extremely small.

As a corrolary of this fourth principle, sub-assemblies to be joined together in final assembly by another operator should be designed so that their parts are held together. They must not come apart during transport, nor require re-assembling or re-positioning by the final operator.

Proper Size of Parts

Fifth way of facilitating assembly operation is to design parts as small as the functional objectives of the product will permit. The purpose of small part size is to enhance easy pick-up and assembly. There is a lower limit to this size reduction, of course, since minor parts cannot be grasped. But too large a part is clumsy to handle and requires greater space on the workbench as well as in the worktray. Prepositioning and positioning of the part take longer if it is large. And with many large parts the operator cannot make a blind grab.

Furthermore, with unnecessarily large parts, the assembler has to spend more time replenishing his supply of components and disposing of finished assemblies.

Observation of the assembly of a great variety of parts, sizes and shapes has indicated that the ideal size range of a part is from the size of a shirt-button to that of a forty-watt lamp bulb. Within this size range hopper bins can be used, thus conserving valuable bench area and allowing more rapid assembly, since a shorter "reach" is obtained.

Elimination of Possibility of Wrong Assembly

Designing the part so that it can be joined to the assembly in only one way saves assembly time. It eliminates the time required by the operator to inspect the part, as well as the time for reflection and making the decision.

In addition, where a part may be assembled in several ways, only one of which is correct, the operator may assemble hundreds of units incorrectly before the error is discovered. Even an experienced operator, equipped with the best possible assembly fixtures, may slip up occasionally and assemble such a part the wrong way. Here again it must be emphasized that it is always the best policy to eliminate the need for operator judgment. Fig. 3 shows five examples of properly designed parts that cannot be misassembled. The terminal at (A) can only be riveted one way because the small lug next to the rivet hole has to engage with an indentation or hole to permit the terminal to seat fully. (B) Stamped mark shown by arrow tells the operator how to hold this piece while she inserts the mating parts through the rectangular slots. The two curved slots of piece (C) are of different lengths, so are the cutouts of part (D) and the lugs of the brass stamping (E); all these parts can be assembled in only one way with their mates.

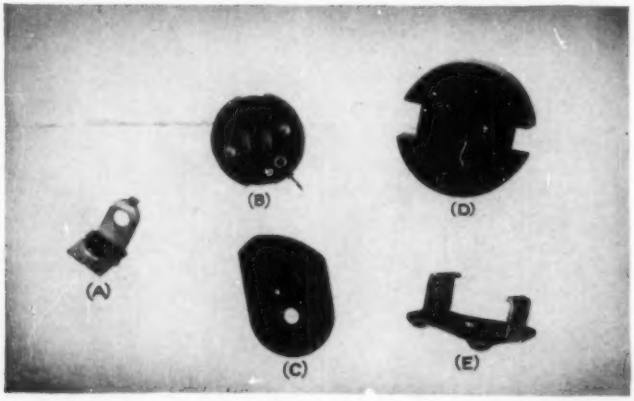

Fig. 3—Assembly time can be minimized by designing parts that can be assembled to their mates in only one way. These five examples are examples of different methods.

Consideration of Assembly Methods

This seventh principle for easy assembly calls for design and production teamwork so that automatic assembly devices can be used wherever feasible. Assembly aids, such as work-feeders and rotary tables, eliminate handling. Furthermore, these devices, rather than the operator, set the cycle.

The designer can encourage and make possible the use of these machines by designing parts for simple mating. For example, all male parts such as screws, prongs and inserts, should be shaped for easy insertion into the female part. Also, to facilitate feeding screws through automatic machines they should have a definite chamfer. Drive screws should be ordered with a plain shoulder and the holes for them should be slightly countersunk to receive them easily.

If a part, such as a knurled insert has to be pressed into some other piece, a plain start, preferably with a chamfer should be allowed. Then the pieces can be pre-assembled by hand and the operation requiring force can then be done with an automatic feed table installed on a press.

A feature of all such parts is that they help align or preposition themselves. This prepositioning function could otherwise be performed only by highly accurate, costly machines.

Table 1—Characteristics of Common Sealing Metals

Metal		Thermal Expansion, units/unit x 10^{-7}		Thermal Conductivity		Specific Resistance, ohms/cm^2x10^6	Heat Treatment Prior to Sealing	Glass Normally Used (Corning Glass No.)	Appearance of Seal	Type of Seal
Type	Designation	25–300 C	77–572 F	Cal/cm^3/sec/deg C	BTU/ft^3/sec/deg F					
Copper	Electrolytic, or oxygen free-high conductivity, copper	165	91.6	0.92	222.8	1.7	None	Theoretically, any	Metallic, red, or yellow	Housekeeper, butt, tubular
Cold rolled steel	SAE 1010, plated or unplated	125	69.5	0.11	26.6	18	Fired in hydrogen atmosphere after plating	Internal: 1990 External: Any soft glass	Unplated: light grey to black	Internal and external
Chrome-iron	28 percent Cr	105	58.4	0.06	14.5	72	Heated in wet hydrogen gas to oxidize	External: 008, 001, 8160, 024 012	Greenish-black	Internal, external
Dumet	Core: 42 percent nickel Copper sheath: 20–30 percent of total weight	Radial: 93 Axial: 60	51.6 33.3	about 0.4	95.8	4.6	None, Borated	008, 001, 012	Metallic, red, or yellow	Internal
Platinum		91	50.6	0.16	38.3	10	None	012, 001, 008, 8160	Metallic	Internal
Sylvania No. 4 alloy	42 percent Ni 6 percent Cr	85	47.3	0.03	7.26	34	Heated in wet hydrogen gas to oxidize	001, 012, 8160	Greenish-black	Internal and others
Molybdenum		55	30.6	0.35	84.6	5.7	None	704, 706, 7052	Light-brown	Internal
Kovar	28 percent Ni 18 percent Co	49	28.2	0.05	12.1	49	900–1100C (1652–2012F) 15–30 min.	704, 7052, 706	Bluish-grey Dark-grey Dark-brownish-grey	Internal, external, tubular
Tungsten		44	24.5	0.38	92.0	5.5	None		Metallic or straw to light brown	Internal

Glass-to-Metal Seals

Criteria for vacuum tight seals between glass and metal. Physical and chemical characteristics of common glasses and metals. Seals and sealing techniques and procedures for various applications.

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GLASS-TO-METAL SEALS are used primarily for two reasons: (1) to bring electric current into a vacuum chamber; or (2) to obtain a visible envelope within which details of construction and operation can be observed under vacuum or under controlled atmospheric conditions. The electronic industry probably uses such seals most extensively, since they are necessary for the manufacture of x-ray, television, radio, and lamp products. Instruments that are to be exposed to unusual weather conditions such as found in the tropics also are sealed off in evacuated or in controlled atmosphere chambers; glass-to-metal seals are used between the cases and windows.

Since a tremendous amount af research work is now being carried on to perfect mass production sealing methods, suitable controls for sealing processes, and new glasses and metals to obtain certain desirable properties, it is appropriate that the technological principles of glass-to-metal seals be reviewed and brought up to date. The discussion in this article will be limited to true glass-to-metal seals—i.e., those in which the glass is in actual contact with the metal or with an intermediate metal oxide layer; solder seals, in which an intermediate material is used for the actual bond, will not be included.

*Formerly Research Engineer Westinghouse Electric Corp.

Criteria for Good Seals

The fundamental requirements for a good glass-to-metal seal are: (1) a close match in coefficients of thermal expansion both during cooling and

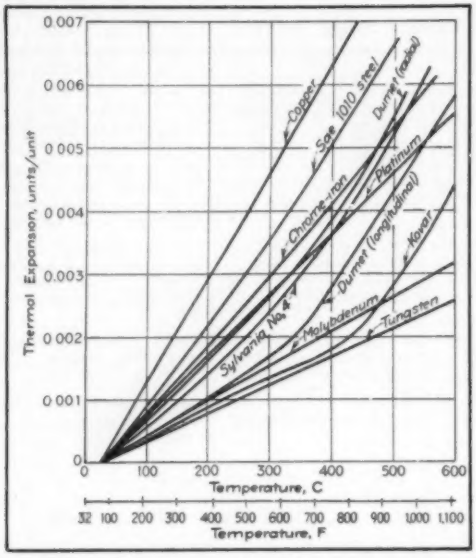

Fig. 1—Thermal expansion curves for metals commonly sealed to glass. Molybdenum, tungsten, Kovar, and copper are normally used with "hard" glasses, as indicated in Table I.

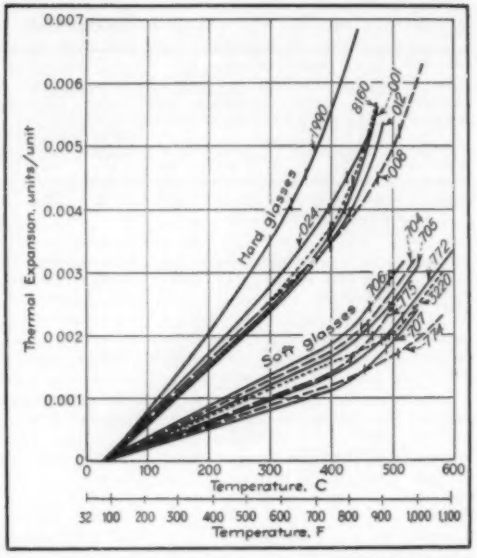

Fig. 2—Thermal expansion curves for common "hard" and "soft" glasses. The vertical marks indicate the annealing range for the materials. The setting point is about midway between.

heating, (2) a glass that will wet the metal at sealing temperatures, and (3) close adherence of the glass to the metal.

If the glass and metal do not have similar thermal expansion rates, stresses will result. Too large a difference will cause mechanical failure since glass is weak and brittle. Sometimes seals are made that, when considered on the basis of normal expansion tolerances, should fail. These, however, are special cases that for the most part are not yet fully understood technologically and would require individual analysis.

Wetting of the metal by the glass is an essential requirement for the development of adherence and vacuum-tightness. It is in effect a close molecular contact that occurs between the metal and glass under oxidizing sealing conditions. Development of good adherence subsequent to wetting is most always associated with a certain amount of oxidation of the metal prior to its wetting by the glass.

The ideal situation would be the existence of one metal and one glass that would be suitable for all seals. This possibility, however, is presently considered improbable because of the great variability of the properties specified by different designs. Consequently, a number of metals and glasses are employed.

The commonly used metals with some of their properties are listed in Table I according to decreasing thermal expansion coefficients, which are a primary factory in selecting sealing materials. In addition, the actual thermal expansion curves are shown in Fig. 1. The relatively pure single-element metals have practically straight-line thermal expansion coefficients, whereas the alloys have an inflection point beyond which the rate of expansion is of greater magnitude—much greater for some than others. The latter type of alloy is considered more advantageous since its expansion rate more closely follows the expansion curve of glass.

The electrical resistivity shown in the table is important in the design of a tube seal since it determines the size of lead necessary to carry a certain current into the evacuated bulb without overheating the wire. Thermal conductivity of the metal is a factor in determining the distribution and rate of dissemination of heat within the bulb. In both cases, overheating of the stem is of primary consideration since it promotes electrolysis and may cause a breakdown of the seal between the leads.

In "heat treatment prior to sealing," the use of metals already degreased is pre-supposed; this operation prevents appearance of bubbles at the seal and promotes good adherence. The characteristic appearance of the seal, determined by the appearance of the glass at the interface, is about the only non-destructive test known for inspection of leads on the production floor. Good appearing seals that are not vacuum-tight are possible, however, and a corresponding check on sealing procedures must be kept to insure consistent high quality.

The glasses normally used with each metal are also included in the table. Other glasses with similar expansion rates but with special properties in regard to dielectric strength, transmission properties, durability, and other properties are available; also, although Corning Glass Works designations are used, similar glasses can be obtained from other companies.

The properties of these glasses are listed in Table II; corresponding thermal expansion curves are shown in Fig. 2. Soft glasses, whose thermal expansion coefficients up to 300 C (572 F) are greater than 50 x 10^{-7} units per unit length per deg C (28 x 10^{-7} units per unit length per deg F) are usually sealed to Dumet, Sylvania No. 4, platinum, chrome iron, SAE 1010 steel, or another metal or alloy whose thermal expansion curve is quite similar. Hard glasses are frequently sealed to copper, Kovar, molybdenum, and tungsten. For safe usage, the difference in expansion coefficients between glass and metal should not exceed 10 x 10^{-7} units per

unit length per deg C, (5.55×10^{-7} units per unit length per deg F). This difference is more critical if the glass has the higher expansion rate.

The annealing range is defined by the strain and annealing points and is indicated on the expansion curves by small vertical marks. These are arbitrarily selected points that have been agreed upon by the glass industry. The lower or strain point is the temperature at which all the strains are relieved or equilibrium is attained in 15 hr, and corresponds to a viscosity of the glass of log 14.6 poises. The upper or annealing point is the temperature at which all the strains are relieved in 15 min and corresponds to a viscosity of log 13.4 poises. The setting point, usually lying about halfway between the two, is considered to be the temperature at which strains begin to appear in the cooling cycle in normal sealing practice, i.e. where the glass becomes sufficiently rigid to support strain with further application of stress.

Special glasses, although not listed in the table, are available for step seals. For instance, if a certain metal and glass whose coefficients of expansion do not match closely enough are specified, then the difference can be spanned by the use of glasses of intermediate expansions in glass-to-glass seals in steps of approximately 10×10^{-7} expansion units.

In examining the properties of the glasses listed, it must be remembered that they have been obtained as closely under equilibrium conditions as possible on properly annealed samples, and that the actual property values will deviate when observed under non-equilibrium conditions.

Physical Considerations in Matching Glass and Metal

Although the coefficient of expansion values usually given for glass are an excellent guide in determining the suitability of the use of a certain glass with a certain metal, a true picture of the stress pattern in the seal can be obtained only by examining the complete plot of the expansion curves. The amount of strain in the seal depends upon the position of the setting point relative to the metal expansion at the same temperature. In other words, no strain appears at the interface of a seal until the temperature drops to the setting point. From that point downward, stress is dependent upon the shape of the expansion curves. This can be shown graphically, Fig. 3, by displacing the glass expansion curve vertically so that the setting point coincides with the metal expansion curve. The spread at room temperature—which is the same as the spread at the setting point temperature in a normal plot—then determines the amount of stress in the seal. If the setting point is below the curve of the metal, the glass will be in compression because it will tend to shrink less than the metal on cooling; if the setting point is above, the glass will be in tension. It is preferable to have the glass slightly in compression.

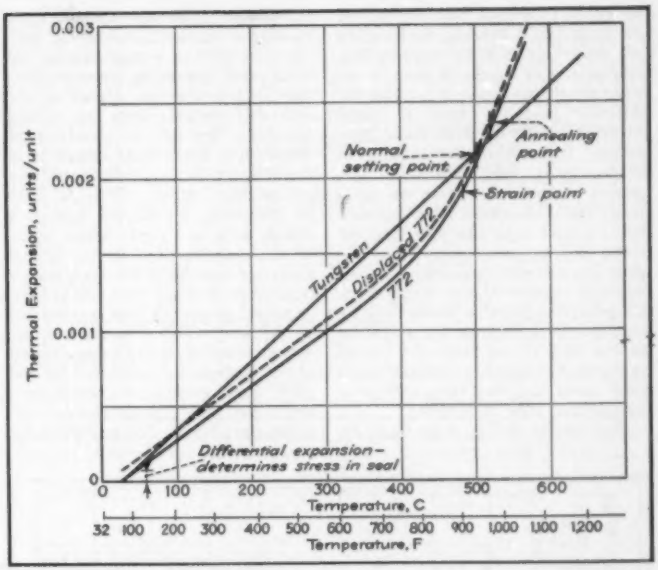

Fig. 3—To determine differential expansion in a glass-to-metal seal, the glass expansion curve is displaced until the setting point is on the metal expansion curve. The spread between the curves then indicates differential expansion, which governs the stress.

Knowing the differential expansion at the setting point, the modulus of elasticity, and Poisson's ratios of the members, the actual stress distribution in a beaded lead can be calculated. This was first accomplished by Hull,

Table II—Characteristics of Common Sealing Glasses

Designation (Corning Glass No.)	Thermal Expansion, units/unit x 10^{-7}		Softening Point		Annealing Point		Strain Point		Log Resistivity, ohms / cu. cm.	
	25–300C	77–572F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	250C-(482 F)	350C-(662 F)
1990	126	70.0	496	927	359	679	334	632	.....	.....
024	96	53.3	607	1123	425	806	397	748	.....	.....
008	92	51.1	696	1284	510	951	475	887	6.335	5.170
8160	91	50.5	627	1162	433	811	399	750	10.560	8.375
001	91	50.5	626	1160	428	804	397	746	9.075	7.125
012	89	49.4	630	1164	433	813	400	753	10.075	7.98
706	50	28.9	690	1274	495	926	463	887	8.46	6.85
704	48	26.7	702	1294	484	902	450	843	9.725	7.945
705	46	25.6	703	1298	496	924	461	862	8.310	6 770
7052	46	25.6	708	1306	480	896	442	828	9.20	7.40
172	41	22.8	915	1680	712	1312	672	1242	12.10	9.90
775	41	22.8	704	1297	467	863	431	808	9.460	7.725
7991	41	22.8	800	1472	565	1050	529	985	8.525	6.970
3320	40	20.2	780	1434	535	994	497	927	8.620	7.055
750	37	20.6	763	1396	498	928	464	867	10.015	8.205
772	36	20.0	755	1392	518	966	484	902	8.815	7.200
774	33	18.3	820	1507	553	1028	510	951	8.150	6.675
707	32	17.8	746	1376	490	.914	455	851	11.175	9.115

Burger and Poritsky, who derived the curves in Fig. 4 showing the variation of the three stresses—longitudinal, tangential and radial—in glass at the interface of the glass and metal for different ratios of bead to metal diameters; identification of these stresses is made in the sketch. In beaded leads, longitudinal and tangential stresses are always of equal sign (that is, in tension when the glass has a higher expansion rate than the metal and in compression when the glass has a lower expansion rate) and opposite to that of the radial stress. Of greatest importance, however, is the fact that in a direction perpendicular to the axis of the lead, the overall radial and tangential stresses cancel each other out and only the true longitudinal stress is observed.

The stresses in Fig. 4 are based on equilibrium conditions. Actually, these conditions seldom occur in a seal. The properties of a glass may deviate appreciably, depending upon its thermal history, and the stresses in the seal will depend upon its cooling schedule. The only accurate way of determining the existing stresses is to first measure the longitudinal strain by photoelastic methods. This is done by immersing the beaded lead in a liquid, such as xylene, whose index of refraction is close to that of the glass, and measuring the strain with a polariscope in which the beam of light is passed perpendicularly to the axis of the lead. The measured retardation is converted to actual stress by use of the stress-optical coefficient for the glass. Then, knowing the longitudinal stress, the other stresses can be estimated from Fig. 4. For example, with a beaded lead in which the glass sleeve is 2.5 times the diameter of the lead and the glass has a lower expansion rate, the glass at the interface will have a compressive longitudinal stress, a tensile radial stress 1.64 greater than the magnitude of the longitudinal stress, and a compressive tangential stress 2.12 greater. If the stress distribution throughout the entire bead is desired, it can be obtained from the curves in Fig. 5 as calculated by Hull and Burger. Similar sets of curves can be calculated for other ratios of glass to metal.

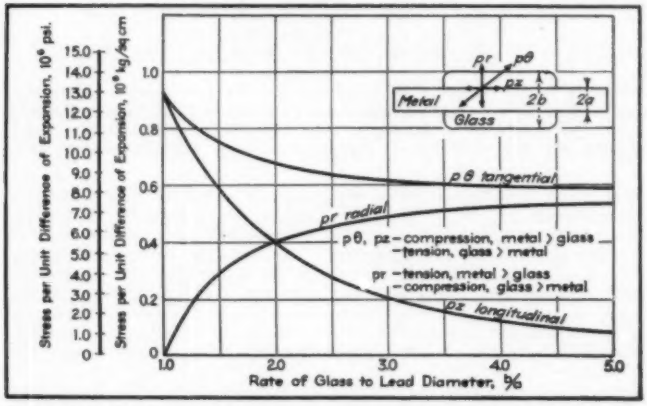

Fig. 4—Principal stresses at the interface of a cylindrical seal as a function of the unit difference of expansion between metal and glass. Equilibrium conditions are assumed.

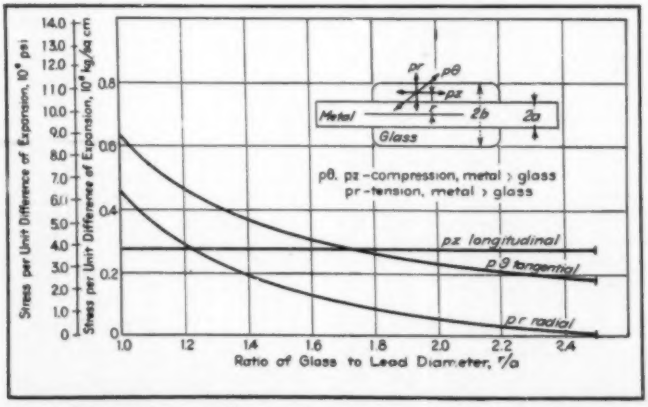

Fig. 5—Principal stresses at distance r from the center of a lead for a glass to lead ratio (b/a) of 2.5, as a function of unit difference of expansion between materials.

Changes in the annealing rate of the seal and its corresponding effect upon the setting point temperature is of great interest to the glass-to-metal seal technologist since the position of this point, as already pointed out, determines the amount of stress in the finished seal. For instance, referring to the glass and metal combination in Fig. 3, it can be seen that in shifting the setting point towards the annealing point the longitudinal stress would change to tension; and in shifting it toward the strain point (by holding the seal at the lower temperature for a longer time prior to cooling) the longitudinal stress would remain as compression, but with a higher value.

Glass is weak in tension, its safe strength usually being quoted as 7,000 to 10,000 psi or 500 to 700 kg per sq cm. Therefore, the seal design and choice of materials usually must be such so as to keep the tensile stresses at a minimum. From Fig. 4 it can be seen that the interfacial stresses as a whole are lower for larger ratios of glass to lead diameter. Consequently, from a standpoint of stresses, especially for materials that do not match too well, the use of the smallest lead wire possible produces the safest seal.

Calculations of stress distribution in cylindrical seals wherein the glass is surrounded by a metal cylinder, recently made by Hull, show all the stresses in the glass to be of the same sign—tensile if the glass has the higher thermal expansion and compressive if the metal has the higher expansion. Consequently, in this type of seal a metal with a higher coefficient of expansion is always used. Fig. 6 shows derived stresses for varying ratios of metal to glass diameters.

Chemical Considerations in Matching Glass and Metal

The primary chemical consideration is wettability of the metal by the molten glass at sealing temperatures. Otherwise, only a physical or partially physical contact of glass to metal re-

sults, and the interface may become a path for infiltration of certain gases and vapors. It has been observed that actual wetting occurs only in the presence of oxygen, thus suggesting that the oxygen serves as a link or bonding force between the glass and metal. These experiments have also shown that the presence of a visible oxide layer is not necessary for wetting to occur.

However, most seals require a certain amount of oxidation of the metal to develop the necessary adherence strength. An often quoted theory states that the oxide acts as a bond between the glass and metal, being soluble in both. It is suggested that the true function of the oxidation rather is to produce a microscopic roughening of the metal. Thus, as the glass dissolves the oxide it comes in contact with the irregular surface of the metal. Upon solidification, the glass becomes mechanically locked to the roughened surface.

The oxide should be sufficiently soluble in the sealing glass so that a continuous oxide layer does not exist in the finished seal. If such a layer is present, strength will not be affected appreciably because the oxide itself has some strength, and the roughened metal surface also provides adherence between the oxide and metal. The layer, however, can become a diffusion path for gases from the atmosphere since most oxides are granular and non-vitreous. In such a case, air gradually infiltrates into the sealed element or else the atmosphere in the element slowly leaks to the outside.

Standard Sealing Procedures

Although sealing techniques may vary slightly from laboratory to laboratory, certain basic steps are generally followed: (1) Cleaning of the metal; (2) oxidation of the metal; (3) application of the glass; and (4) annealing.

CLEANING. Thorough cleaning and degreasing of the metal is necessary since impurities on the surface will lead to the formation of bubbles at the interface and also interfere with wetting. Wet hydrogen-baking, for some of the metals, as indicated in Table I, serves to eliminate bubble formation during sealing. This may be due either to displacement of dissolved gases by more easily removable hydrogen, oxidation of carbonaceous material in the metal, or removal of surface adsorbed materials untouched by or deposited after cleaning.

OXIDATION. Controlled oxidation of the metal is necessary to obtain a tight seal, as already discussed. The exact time and temperature cannot be specified since the mass of the metal and type of furnace will have an effect on the formation rate of the oxide layer but once the correct oxidizing conditions are established, they should be rigidly adhered to. For instance, Fig. 7 shows such oxidation data for small pieces of Kovar, with the range leading to satisfactory seals indicated. If there is an insufficient amount of oxide, the adherence may be poor but the seal will be vacuum-tight. If too much oxide is present, the glass will not penetrate it, and the resulting seal will be strong but not vacuum-tight just as when a glass with low solubility is used.

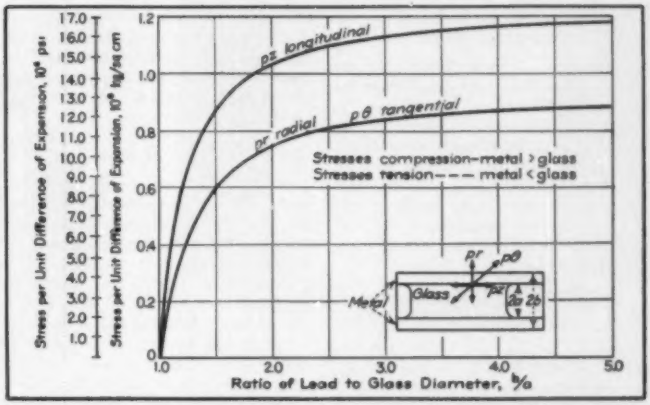
Stress per Unit Difference of Expansion, 10⁶ psi
Stress per Unit Difference of Expansion, 10⁶ kg/sq cm
pz longitudinal
pr radial
pθ tangential
Stresses compression—metal > glass
Stresses tension— — — metal < glass
Metal
Glass
Ratio of Lead to Glass Diameter, b/a

Fig. 6—Principal stresses at the interface of an external seal under equilibrium conditions, as a function of the unit difference of expansion between the metal and the glass.

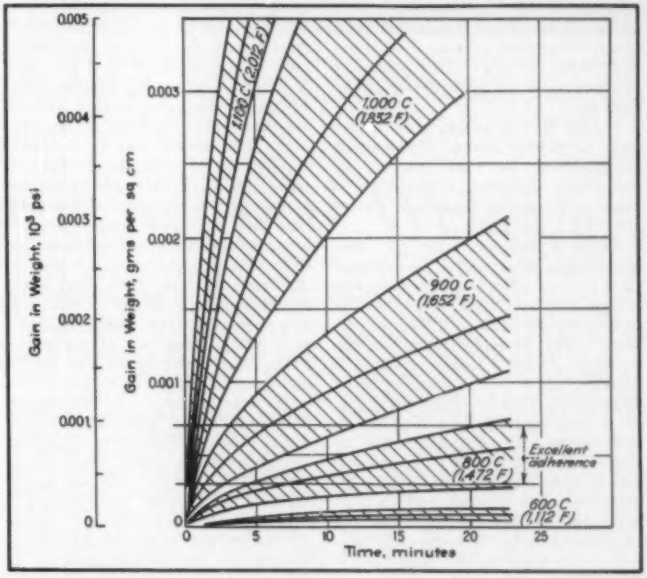
Gain in Weight, 10³ psi
Gain in Weight, gms per sq cm
1,100 C (2,012 F)
1,000 C (1,832 F)
900 C (1,652 F)
800 C (1,472 F)
600 C (1,112 F)
Excellent adherence
Time, minutes

Fig. 7—Oxidation rate, as a function of time and temperature, for small pieces of Kovar. Too heavy an oxide film promotes leakage, but a thin film is necessary.

APPLICATION. The application of the glass or sealing can be accomplished manually by skilled operators, mechanically by machines, or by a combination. The technique involved lies in applying the glass as quickly as possible to keep the additional oxidation during sealing at a minimum, and

in applying sufficient heat to allow the glass to dissolve the oxide.

ANNEALING. The importance of annealing should be recognized from the previous discussions on stresses in seals. The necessity for annealing so that the non-equilibrium stresses within the glass itself are removed and for choosing an annealing schedule that will locate the setting point at the most desirable temperature for the particular seal, however, may be mentioned again.

Special Sealing Techniques

Excessive oxidation of the metal in some large or intricate seals is sometimes difficult to avoid during sealing, but can be minimized in a number of ways. A glass bead or sleeve can sometimes be applied to the sealing portion of a lead, which then is subsequently sealed into a stem or a glass envelope; the smaller amount of glass allows easier manipulation and better application of heat. This procedure is common in tungsten and molybdenum seals.

Dumet wire is coated with a thin layer of sodium borate. This coating accomplishes the same purpose by controlling the rate of oxidation of copper. Copper is sometimes treated similarly.

More recently, a report has been made by the writer on the development of a powder glass or glass-enameling technique of application of a thin glass coating to the sealing surface of the metal. The method consists of dispersing powdered sealing glass in a suitable liquid, and of applying it by spray or dip to an oxidized metal surface. The piece is then fired in an oven under controlled conditions of time and temperature. Subsequent sealing then evolves into a glass-to-glass seal since the seal itself is protected by the glass coating. The advantages of such a technique are twofold: (1) Seals can be made under controlled conditions of oxidation and sealing so that the success of the seal is not dependent upon the skill of an operator, thus lending itself well to mass production; and (2) special and complicated seals can be made successfully.

Types of Seals

Almost any conceivable shape or design of seal is possible providing the thermal expansion coefficients of the glass and metal are close and satisfactory adherence is obtained. The more common designs are classified in a general way in Fig. 8: An internal seal in which a metal rod is enclosed by glass; an external seal, glass enclosed by a metal cylinder; tubular seal, metal cylinder sealed to a glass cylinder; edge seal, metal cylinder sealed into a glass surface (tubular, if metal is tubular shaped and non-tubular, if not); butt seal, glass cylinder sealed to a flat piece of metal; window seal, flat piece of glass sealed unto annular opening in a flat piece of metal; and combination seals, which, as the name implies, can be any combination of those mentioned.

A Housekeeper seal is a special modification of a tubular or edge seal with which a metal, such as copper, with a much higher thermal expansion than the glass, can be used. The technique consists of machining the sealing edge thin enough so that it can be deformed by the glass, thus compensating for the differences in expansion. This procedure can be employed to a certain extent on all metals but lends itself especially well to copper because of its high ductility and low yield point. Copper is used extensively with Pyrex glass, No. 774, in which case a difference in expansion coefficients up to 300 C (572 F) of 132 x 10^{-7} units per unit per deg C exists. (73.3 units per unit per deg F.)

In general, the smaller the seal or the shorter the length of the sealing surface, the less danger there is of leakage. In making seals, sharp corners and re-entrant angles in the glass and at the seal should always be avoided since they become points of stress concentration. Fillets should be used wherever possible.

REFERENCES

Glass-to-metal seal technology is an extensive and complicated field. To cover the subject in a relatively short space its treatment has necessarily been general. Those who are interested in pursuing the subject further and in greater detail can consult the following references:

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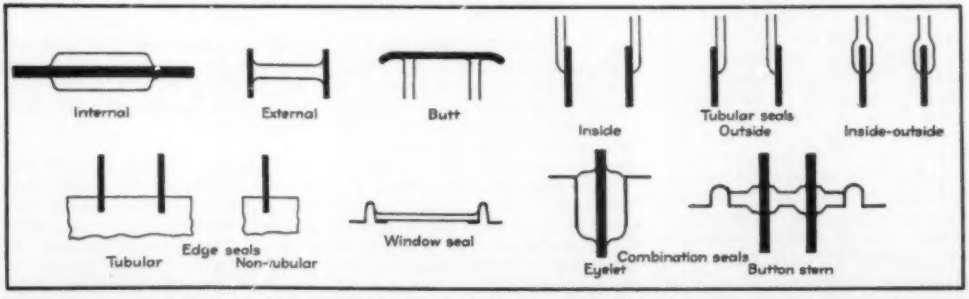


Fig. 8—Common types of seals. As indicated in Table I, not all of the seals are suitable for the various glass and metal combinations.

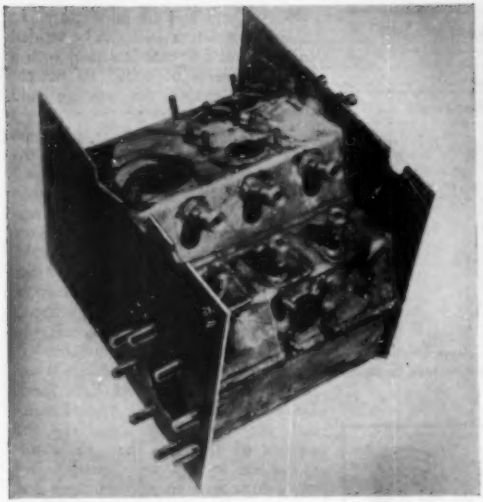


Fig. 1—Fabricated compressor housing assembled by a combination of arc and stud welding. The studs are located by means of sheet metal templates. A tripod on the welding gun insures perpendicular location and simplifies the stud welding operation.

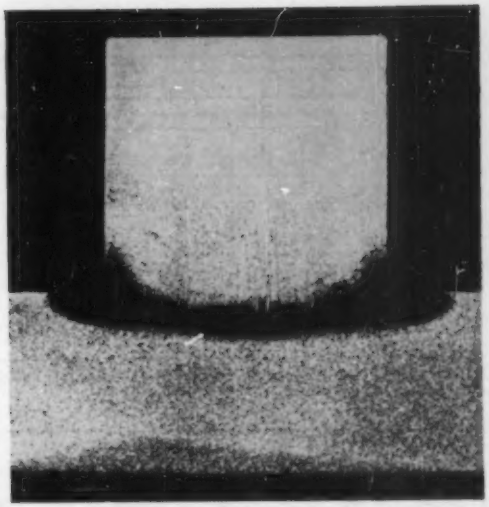


Fig. 2—Enlarged cross section of an end-welded stud showing the fusion between the stud and the parent metal. The strength of such welds depends primarily on the type of stud used, on the stud material and diameter, and on the base material.

Design Details for Stud Welding

Minimum plate thicknesses for different sizes of studs, strength of studs, required clearances for the welding gun, methods of stud location, and basic functional advantages of the process.

R. W. MURDOCK
Nelson Stud Welding Division
Morton-Gregory Corporation

BECAUSE OF REPLACEMENT REQUIREMENTS, maintenance purposes, or for basic design considerations, metal parts often must be assembled with removable type fasteners. In heavier construction, the conventional way of attaching such fasteners is to drill and tap holes through the plate or structure and insert studs, but this method may limit the design of the finished assembly so that it is neither the most efficient nor practical. As a result, such methods of attachment frequently increase production costs and manufacturing difficulties.

If such is the case, stud welding can be used to advantage. With this process, the fastener can be end-welded to the surface without prior drilling and tapping. The equipment consists of a special welding gun, a timer and control unit, a d-c welding generator, special fluxed studs of weldable material, and ceramic ferrules.

When a weld is made, the stud and protective ferrule are chucked in the gun and pressed against the work. The switch on the gun is pulled, and a solenoid lifts the stud $\frac{1}{16}$ in. above the work to create an arc between the stud and the base metal. The timer unit controls the length of the weld cycle; at the proper time the solenoid is automatically de-energized and the stud plunged into the pool of molten metal. The ceramic ferrule, which surrounds the stud tip and butts up against the work, functions to (1) shield the molten metal to prevent oxidation; (2) to contain the molten metal in the weld area; (3) to control the form of the fillet resulting from the weld; (4) to concentrate the heat in the weld area, and (5) to shield the arc. Because of the shielding effect of the ferrule, in conjunction with the use of self-contained flux in the studs, stud welding may be classed as a shielded-arc welding process. As seen by the cross-section illustration, Fig. 2, complete fusion results between the stud and the parent metal.

The controlled welding cycle makes for rapid, semi-automatic stud application. Other major advantages of the process are: (1) all work can be done from the outside of the structure; (2) no surface preparation is required; (3) design simplification and improvement in appearance are often feasible; and (4) the interior of the structure remains smooth.

Design Considerations

The conditions that must be met before stud welding can be considered can be grouped into three general categories. Obviously, the stud and the structure to which it is to be joined must be weldable. Secondly, the size and shape of the stud must be such that a ferrule can be used, the stud can be chucked in the welding gun, and sufficient power is available to heat the metal to a welding temperature. And lastly, certain details, such as clearance for the welding gun and the stud, flatness of surface, thickness of the plate, and others—must be

Table I—Minimum Plate Thicknesses for Different Sizes of Stud[1]

Stud Dia., in.	Plate Material, in.			
	Mild Steel		Stainless Steel	
	With Back-up	Without Back-up	With Back-up	Without Back-up
1/8	0.036	0.036	0.030	0.036
3/16	0.036	0.036	0.036	0.059
1/4	0.036	0.048	0.048	0.059
5/16	0.048	0.054	0.048	0.075
3/8	0.054	0.060	0.059	0.075
7/16	0.078	0.090	0.075	0.105
1/2	0.090	0.105	0.105	0.135
5/8	0.125	0.125	0.135	0.188
3/4	0.156	0.156	0.188	0.250

[1]For welding without burn-through or excessive distortion. Heavier sheets may be necessary to realize the full strength of the threaded section.

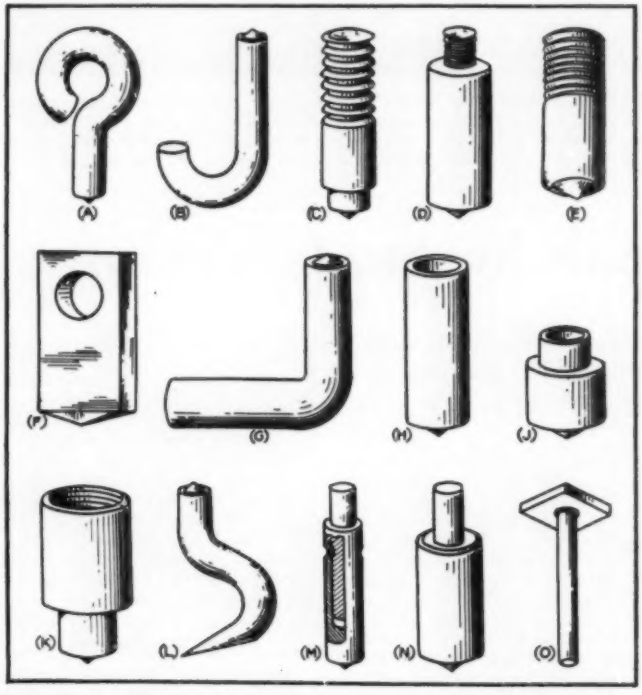


Fig. 3—Typical stud shapes: (A) eye-bolt, (B) J-bolt, (C) standard M-G, (D) threaded shoulder, (E) straight threaded, (F) rectangular, (G) bent, (H) female drive screw, (J) female shoulder, (K) female threaded reduced base, (L) meat hook, (M) composite aluminum rivweld, (N) rivweld, (O) square head. Only requirements are that the stud can be chucked and that a ferrule can be used.

taken into consideration in the design stage.

Insofar as materials are concerned, the same general limitations that apply to arc welding also apply to stud welding. Mild steels up to 0.30 percent carbon can be joined without preheat, and higher carbon steels can be welded provided that the area is preheated before striking the arc. Stainless steels either of the austenitic or martensitic type can be welded, although the austenitic types are preferred. AISI grades 302, 304, 307, 309, 310 and 347 are satisfactory. In addition, stainless studs can be welded to either mild or stainless steel with a power increase of about 10 percent over that required for welding mild steel studs.

Low alloy, high tensile steel can also be welded without preheat if the carbon content is held to 0.12 percent maximum, and some success has been had with other ferrous alloys. For example, Monel studs have been joined to Monel sheet where corrosive conditions warranted the additional cost. Some progress also has been made in the non-ferrous field, but such applications still are considered as being in the more or less "special" category.

Of course, not all sizes of studs can be welded to all gages of light sheet. Limiting factors are the type of material, the strength required, and the amount of distortion that can be tolerated. In Table I are shown the relationships between stud diameter and minimum sheet thickness for mild and stainless steels. Although these minimum thicknesses may have to be increased for maximum strength, they are satisfactory for welding without burn-through or excessive distortion.

Standard shapes in which studs are formed are straight, hooked, rectangular, and special-purpose, which includes those such as retaining pad types for holding insulation or firebrick in furnace applications, insulated types for electrical applications, or split types. Sketches of some of these are shown in Fig. 3.

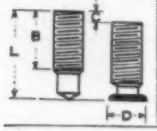
Straight, mild-steel threaded types range from $\frac{1}{4}$ to $\frac{3}{4}$ in. in diameter, and from $\frac{1}{2}$ to 8 in. or longer in length; the maximum diameter of stainless steel types is $\frac{3}{8}$ in. Critical dimensions of studs and ferrules are given in Table II. Actually, the limit on stud diameter is governed not by the capacity of the welding gun, but by the size of welding generator that is available: a NEMA d-c generator rated at 400 amperes is required for studs up to $\frac{1}{2}$ in. diameter.

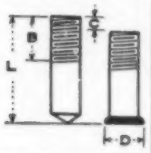
Inasmuch as a portion of the stud is melted at the same time a molten pool is created in the plate by the welding arc, there will be some loss in stud length, according to the time and heat used in the welding cycle. Normally $\frac{1}{8}$ in. is allowed for burnoff. This allowance may decrease when studs are applied to very thin plate and the cycle is short; on the other hand, it may increase when studs are welded to medium carbon steel and an extra amount of heat is used to slow the cooling rate of the weldment.

Other points that will be noted in Fig. 3 are that either blank studs or threaded types—American Standard

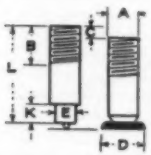
Table II—Critical Dimensions of Studs and Ferrules

STUDS

Standard M-G Studs	Stud Dia. in.	Stud Length "*L*", in.		Threads per in.	Thread Length "*B*", in.		Burn Off, in. ("*C*" ± 1/32 in.)	Fillet Dia. ("*D*" + 0.02 in.)
		Min.	Max.		Stud Length Up to 2 1/2 in.	Stud Length Over 2 1/2 in.		
	1/4	1.0	3.0	20	*L*— 3/8 in.	2.0	1/16	0.275
	5/16	1.0	3.0	18	*L*— 3/8 in.	2.0	3/32	0.330
	3/8	1.0	3.0	16	*L*— 3/8 in.	2.0	3/32	0.406
	7/16	1.0	3.0	14	*L*— 3/8 in.	2.0	1/8	0.468
	1/2	1.0	3.5	13	*L*— 13/32 in.	2.0	1/8	0.546

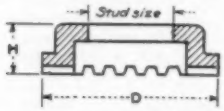
Full-base Studs	Stud Dia. in.	Stud Length "*L*" in.		Threads per inch		Thread Length "*B*", in.			Burn Off ("*C*" ± 1/32 in.)	Fillet Dia. ("D" + 0.02 in.
		Min.	Max.	NC	NF	Stud Length Up to 1.0 in.	Stud Length 1 1/8 to 1 7/16 in.	Stud Length 1 1/2 in. or Over		
	No. 6	13/16	8.0	32	40	*L*— 3/16	1.0	1 1/4	3/32	0.190
	No. 8	13/16	8.0	32	36	*L*— 3/16	1.0	1 1/4	3/32	0.214
	No. 10	13/16	8.0	24	32	*L*— 3/16	1.0	1 1/4	3/32	0.262
	1/4	13/16	8.0	20	28	*L*— 3/16	1.0	1 1/4	1/8	0.330
	5/16	13/16	8.0	18	24	*L*— 3/16	1.0	1 1/4	1/8	0.406
	3/8	13/16	8.0	16	24	*L*— 3/16	1.0	1 1/4	1/8	0.468
	7/16	13/16	8.0	14	20	*L*— 3/16	1.0	1 1/4	1/8	0.546
	1/2	7/8	8.0	13	20	*L*— 3/16	1.0	1 1/4	1/8	0.613
	5/8	15/16	8.0	11	18	*L*— 1/4[1]	...	1 1/2[2]	1/8	0.765
	3/4	1 1/4	8.0	10	16	*L*— 1/4[3]	...	1 3/4[4]	1/8	0.890

[1]For stud length 1 1/16 in. or less
[2]For stud length 1 15/16 in. or less
[3]For stud length 1 1/2 in. or over
[4]For stud length 1 3/4 in. or over

Reduced-base Studs	Stud Dia., in.	Stud Length "*L*", in.		Length of Base in. "*K*"	Weld Dia. "*E*"	Threads per inch		Thread Length "*B*", in.			
		Min.	Max.			NC	NF	Stud Length Up to 1 3/8 in.	Stud Length 1 1/2 in. or over	Burn Off ("*C*" ± 1/32 in.	Fillet Diameter ("*D*", + 0.02 in.)
	No. 8	13/16	8.0	9/64	1/8	32	36	L-K	1 1/4	1/16	0.169
	No. 10	13/16	8.0	9/64	9/64	24	32	L-K	1 1/4	1/16	0.192
	1/4	13/16	8.0	5/32	3/16	20	28	L-K	1 1/4	1/16	0.255
	5/16	13/16	8.0	1/4	1/4	18	24	L-K	1 1/4	3/32	0.343
	3/8	13/16	8.0	1/4	5/16	16	24	L-K	1 1/4	3/32	0.406
	7/16	13/16	8.0	9/32	3/8	14	20	L-K	1 1/4	1/8	0.468
	1/2	7/8	8.0	9/32	7/16	13	20	L-K	1 1/4	1/8	0.560

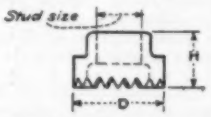
FERRULES

M-G Ferrule



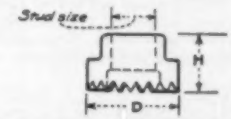
Stud Size, in	Ferrule Dia. "*D*" ± 0.015, in.	Ferrule Height, "*H*" ± 0.015, in.
1/4	0.390	0.250
5/16	0.535	0.250
3/8	0.595	0.250
7/16	0.675	0.250
1/2	0.740	0.281

Full-Base Ferrule



Stud Size, in.	Ferrule Dia. "*D*" ± 0.015, in.	Ferrule Height, "*H*" ± 0.030, in.
No. 6	0.375	0.422
No. 8	0.375	0.422
No. 10	0.375	0.422
1/4	0.455	0.422
5/16	0.578	0.422
3/8	0.640	0.438
7/16	0.703	0.438
1/2	0.795	0.468
5/8	1.030	0.546
3/4	1.180	0.546

Reduced-Base Ferrule



Stud Size, in.	Ferrule Dia. "*D*" ± 0.015, in.	Ferrule Height, "*H*" ± 0.030, in.
1/4	0.455	0.422
5/16	0.578	0.422
3/8	0.640	0.438
7/16	0.703	0.438
1/2	0.795	0.468

Table III—Average Fracture Strength of Stud Welds

Type of Stud	Load at Fracture (tension, lb.; torsion, in.-lb.)									
	1/4 in Stud		3/8 in. Stud		1/2 in. Stud		5/8 in. Stud		3/4 in. Stud	
	Tension	Torsion	Tension	Torsion	Tension	Torsion	Tension	Torsion	Tension	Torsion
Blank stud, full diameter	3,700	250	8,300	840	14,700	1,980	23,000	3,300	33,000	5,800
Blank stud, 1/2 reduced base	2,700	155	7,800	740	14,000	1,560	22,400	3,180	32,400	5,180
Blank stud, full reduced base	1,250	50	5,500	310	13,300	1,300	19,900	1,880	25,400	3,200
Threaded stud, U. S. Std. Coarse	3,300	170	5,200	590	13,200	1,400	20,200	2,400	30,600	4,100

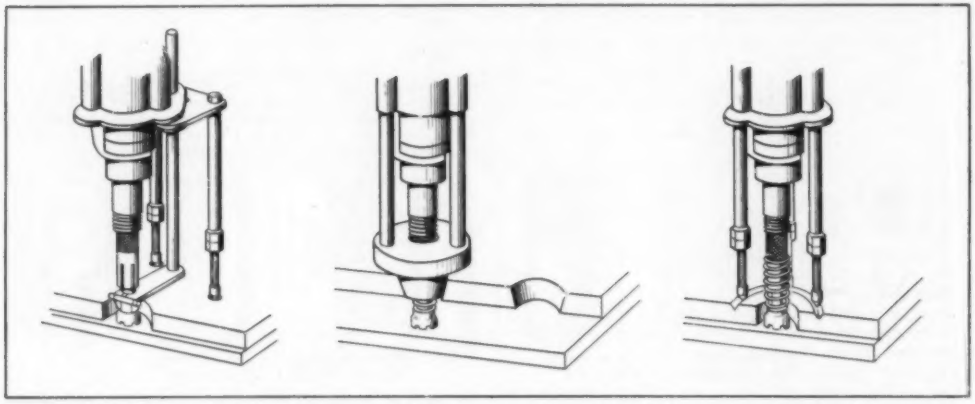


Fig. 4—Studs and ferrules may be located with templates by any of several methods: by means of holes in the template for gun adapter legs, left; by a tapered hole in the template for another type of gun adapter, center; or by a concentric groove.

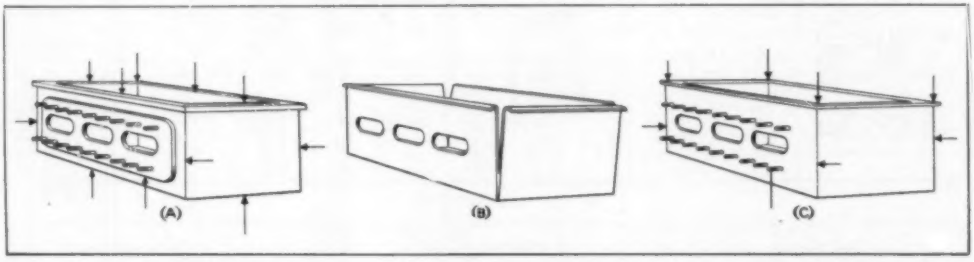


Fig. 5—The use of end-welded studs and sheet metal construction saves weight and manufacturing costs in the production of these switchgear boxes. The conventional design (upper left) requires heavy flanges and bosses to obtain sufficient tapping depth. The flange at the top is replaced by bending the side plates to form the gasketing surface, and studs end-welded to the plate material eliminate the need for the heavy bosses on the side of the box. The appearance also is cleaner than before.

NC or NF threads—are available, and that the diameter may be full or reduced at the base. Principal advantage of the reduced base type is that it minimizes the problem of clearance caused by the welding fillet. For example, a standard ½ in. stud produces a fillet diameter of 0.613 in. An M-G of the same diameter has a fillet diameter only 0.046 in. greater than the stud; but a reduced base stud has an even smaller fillet—although it is obtained at some sacrifice in strength, as indicated by the values in Table III.

There are, of course, other ways of designing around this weld fillet. If two metal plates are to be joined without an intervening gasket, counterboring will take care of it. When gaskets are required, careful selection of the material and the dimensions will minimize the fillet problem. Other ways of accommodating the weld fillet are by an oversized hole in the cover plate, or by dogs or clamps to hold the plate in position.

Partly because of the weld fillet and partly because of the clearance required for the ceramic ferrule and the welding gun, spacing between studs and minimum distances between studs and openings in the plate are limited. For the same reasons, the proximity of studs to flanges and other raised elements is limited. Minimum recommended clearance dimensions for common types of studs are indicated in Table IV. Height clearance problems are minimized, as is the handling of extra-length studs, by use of accessory offset chucks.

Positioning the studs on the work is

accomplished by any of several methods, the simplest of which is to center punch the proper stud location on the work. Accuracies of $\frac{1}{32}$ in. are possible with this method.

When closer tolerances are desired, templates can be made of light gage metal. Holes are drilled in the template to locate the ferrule—which, in turn, locates the stud—and the template is then positioned over the work with pins, slots, or other devices. A minimum of $\frac{1}{16}$ in. between the template and the work piece is required to allow the gases to escape. Other techniques may be applied, Fig. 4, whereby the stud is located indirectly by referencing gun legs or special adaptors that are attached to the gun. The method used will be determined by the requirements of the particular application. Note that the techniques illustrated not only locate the stud, but provide a means for maintaining perpendicularity as well. When offset legs are used for positioning the stud, the hole drilled in the template for the stud and ferrule is made large enough to provide adequate venting of the hot gases, and the template then fits flush against the work; accuracies of 0.025 in. are obtainable.

In some instances it is preferable to establish a fixed production unit for use in end welding studs to other components. Push buttons and hydraulic cylinders replace manual positioning and trigger actuation of the hand welding gun. As in the case of templates used with the portable gun, the degree of accuracy required and the amount and type of work to be done determine the size and character of the production unit. A simple production unit can be made by attaching a portable gun to a permanent stand such as a drill press. With a locating jig for the work, it is possible to accurately weld studs to small components with considerable speed.

When higher production rates make feasible a greater degree of automaticity, single or multiple-gun production units of a wide range of size can be designed to accommodate individual manufacturing requirements. Automatic indexing and feed controls, positioning devices, and similar features make possible production rates of 20 or 30 welds per minutes on some designs. Because of the rigidity of the mounting structure, tolerances of 0.005 in. on location and 0.010 in. in height are practicable. In one automotive application, a fixed production unit is used to weld studs at a slight angle to a sharply curved bumper guard surface. Somewhat similar setups have been used to weld studs to convex or concave surfaces having a diameter as small as $\frac{3}{8}$ in. Besides several other automotive applications, fixed production units have been used in the manufacture of large pressure vessels and for welding pins and teeth to combing machines. In applications like the latter, the production unit is arranged to move the work so that the studs are applied in a particular path or pattern.

The strength of stud welded fasteners varies with the material of which the stud is made, the material of the plate, the size of the stud, the welding cycle employed, the shape of the stud, and on numerous other factors. Mild steel, which is commonly used for studs, has a tensile strength of 75,000 psi and a yield strength of 60,000 psi, an elongation of 24 percent in 2.0 in., and a reduction in area of 58 percent. The fracture strength of welds on this material are listed in Table III.

Tests show that the ultimate strength of a properly welded stud is determined by the smallest cross-section of the stud; stud failure may thus be anticipated before weld failure. Comparative tests between stud welding and hand arc welding indicate that the stud welded joint is usually superior in strength to a hand welded joint in static tension, impact tension and torsion. The increase in strength is attributable to the fact that the controlled stud welding cycle produces a fusion weld across the entire base of the stud.

Advantages of the Process

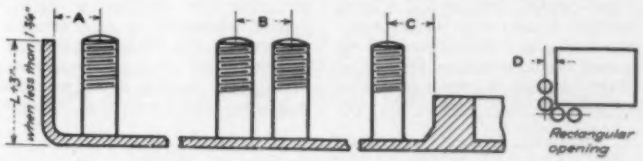
If proper attention is given to design details, there are numerous advantages that are obtained by substituting welded studs for those that are attached by drilling and tapping through-holes. These advantages can be summarized as follows:

PRODUCTION TIME. Reduced production time is a feature of stud welding, not only because drilling and tapping is unnecessary and no surface preparation is required, but also because the only jigs and fixtures required are of simple construction and hence set-up time is reduced. Production rates average 5-6 welds per minute for a hand-operated welding gun, or 6-30 welds per minute for an automatic unit.

MANUFACTURING COSTS. Cost reductions through stud welding often are appreciable. Of equal importance in many cases is the fact that weight of the workpiece itself is considerably lowered. These points are illustrated by the switchgear housing, Fig. 5. Heavy bosses and flanges usually must be added to the conventional box, *A*, to insure that there is sufficient depth of material to withstand the loads imposed on tapped threads. In the redesigned model, the flanges at the top are formed by bending the side plates on a press brake, and end-welded studs on the side *C* eliminate the need for heavy bosses.

LOAD DISTRIBUTION. Studs can be placed in proper relation to the load each must carry, which often is impractical if work must be done from the blind side. For example, if a container is to be drilled and tapped for through bolts, account must be taken of possible interference from some internal structure or condition when inserting the bolts—and consequently, such bolts cannot always be so placed

Table IV—Minimum Stud Clearances



Stud Dia., in.	Clearance, in.			
	A	B	C	D
3/16	Bend radius + 5/16	1/2	Weld width + 1/4	1/2
1/4	Bend radius + 5/16	9/16	Weld width + 1/4	9/16
5/16	Bend radius + 3/8	11/16	Weld width + 5/16	11/16
3/8	Bend radius + 3/8	3/4	Weld width + 5/16	3/4
7/16	Bend radius + 13/32	13/16	Weld width + 3/8	13/16
1/2	Bend radius + 15/32	15/16	Weld width + 7/16	15/16
5/8	Bend radius + 9/16	1 3/32	Weld width + 1/2	1 3/32
3/4	Bend radius + 5/8	1 7/32	Weld width + 9/16	1 7/32

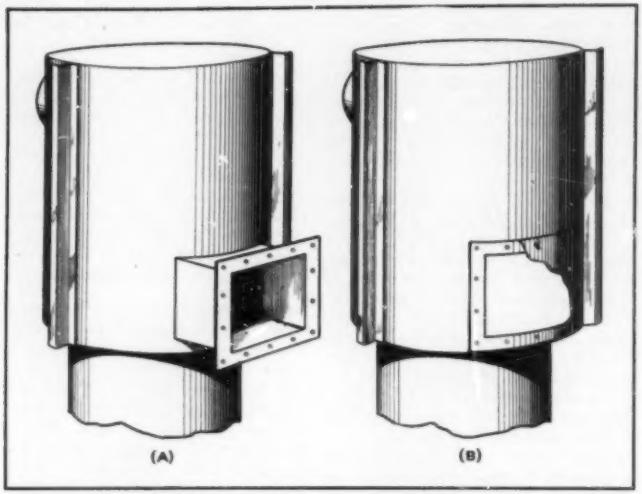


Fig. 6—How the design of access doors can be simplified by stud welding. Conventional construction *A*, has a rectangular opening welded to the main structure; the inspection cover is then bolted to the flange. Simplified construction *B* has studs welded directly on the surface; the cover plate is fastened in place by wing nuts

that they carry their proper share of the total load on the structure.

INTERIOR SURFACES. Since no drilling is involved interior surfaces of tanks, blowers, and pressure vessels are smooth and unobstructed. This is especially important in the fabrication of large industrial fans, because internal projections interfere with the normal flow of the air stream, and promote the collection of dirt accumulations which further reduce efficiency.

A related advantage occurs when studs for covers of access doors or inspection openings are welded to pressure vessels or furnaces. Good design practice—and some national safety codes—prohibit drilling and tapping bolt holes in the casings of such equipment. Also, stud welded fasteners can be used to hold insulation, firebrick, or similar materials to interior or exterior surfaces; for such applications, specially designed studs are available.

Still another application where smooth internal surfaces are important is in the production of cold walls for food processing equipment. External plug welding provides the necessary spacing for walls for milk coolers and pasteurizers, for example, without effecting the inner surface.

CORROSION. Elimination of "through" holes also minimize the problem of corrosion in pressure vessels and fluid-handling equipment of all kinds. When a smooth unbroken internal surface is maintained, no convenient toehold is provided for damaging corrosion. For example, better corrosion protection was obtained on underground switchboxes for communication equipment. The former construction involved a cast housing and extensive drilling and tapping operations; the redesigned units are made of stainless steel plates, on which studs are end-welded.

DESIGN SIMPLIFICATION. Mention has already been made of examples of design simplification, for decrease in cost and product improvement usually follow design improvement. An obvious example is the furnace cleanout access door shown in Fig. 6. As indicated in the sketch, the former construction consisted of a box-like structure hand-welded to the boiler. The inspection cover was then bolted to the flange around the box. Necessary because internal holes would introduce the possibility of gas leakage, this external flange arrangement was a difficult and costly one and, further, greatly limited accessibility to the interior of the furnace. The built-up components was replaced by studs which are end welded to the boiler surface. The cover plate was then fastened in place with wing nuts.

BROADER APPLICATION RANGE. When conventional studs are used, both the size of structure involved and the point in the manufacturing cycle at which studs can be applied may be limited by the fact that drilling and tapping are necessary preliminary operations. Studs may be conveniently applied in a large structure in the assembled state, for example, much more simply than in the separate components.

Boiler and processing equipment manufacturers, on the other hand, may apply stud welding in the field to complete the assembly of separate components. The five-pound stud welding gun may be operated with 300 feet or more of cable in any position, on the other hand, which greatly broadens its application range.

Under the proper conditions, the work may even be used in assembly as a locating template to position studs to complete fabrication, eliminating troublesome problems involved in supplying precisely dimensioned prefabricated components.

"Brain" Predicts Path of Giant Rockets in Laboratory

ANOTHER GIANT COMPUTING MACHINE of the electronic type predicts and records every movement that a giant missile would make in the air from take-off to landing without even shooting the missile into the air. It senses every waiver, dip and spiral the bomb would take if actually fired, and records where and when the landing would occur.

BEMAC is the name selected for the new non-arithmetic device. It does not completely outmode the traditional gathering of information by actual test flights of missiles, but its use for numerous problems will save many thousands of dollars in time and material required in field experimentation.

The record of the imaginary flight of a particular missile is made with a high-speed motion picture camera that photographs a series of moving dots on the screen of the computer. The computations are recorded so that they actually look like a missile flight in the viewer or in the permanent record of the visual scope made by the camera.

The new design is for use with the Boeing Airplane Company GAPA ground-to-air pilotless missile project being completed for the United States Air Force.

Metal-Ceramics

Abstracted from "Metal-Ceramics, A New Field in Powder Metallurgy" by Dr. Henry H. Hausner, Proceedings of Fourth Annual Spring Meeting, Metal Powder Association, 420 Lexington Ave., New York 17, N. Y.

METAL-CERAMICS refers to a process similar to power metallurgy and ceramics. The metal-ceramic products, called "cerametallic" materials or "Ceramals," are mixtures or other combinations of metal powders with materials such as powdered silicates and metal oxides. Products of this type are the cemented carbides, the metal powder reinforced plates and friction materials, and metal-diamond materials for tools.

Present research in cerametallic compositions covers two essentially different groups:

1. Mixtures of metallic and ceramic powders.

2. Combinations using different layers of metal powders and ceramic powders.

Some of these mixtures are developed to form electrical semi-conducting materials of electrical resistors. Other mixtures and some of the multilayer materials are developed to form high temperature resisting, non-corrosive materials. Multi-layer materials can also be developed for electrical products such as condensers.

Solid metals and sintered metals are generally good electrical conductors. Their electrical resistances increase with increase of temperature; their temperature coefficient of resistance is positive. Experiments have shown there are exceptions: Very thin films of copper, and of some other metals, have a lower electrical resistivity than that of standard metals, and their temperature coefficient of resistance is negative.

Ceramic materials are electrical insulators or poor conductors. Their resistivity decreases with increase of temperature; they have a negative temperature coefficient.

Cerametallic semi-conductors are mixtures of conducting and insulating materials. Their temperature coefficients of resistance can be developed according to specifications. They can be made to possess a positive temperature coefficient at low temperatures and a negative temperature coefficient at higher temperatures, or a negative temperature coefficient at low temperatures and a positive one at elevated temperatures.

In Tables I and II are given respectively the electrical properties of ZrO_2-Fe_2O_3-Cu compositions and TiO_2-Ni compositions.

An important development of Ceramals is in the field of high temperature resisting materials. Table III gives the melting points of some metals, their respective oxides, and silicates or mixture of their oxide with SiO_2. With the exception of titanium, the melting points of the metals are much lower than those of the respective oxides. The melting temperatures of the silicates are generally between those of the metals and the oxides.

Metals are generally characterized by by a certain ductility and mechanical strength. They withstand temperature shocks, but they corrode at high temperatures, thereby losing their strength.

Ceramic materials are poor in tensile strength, although some are high

Table I—Electrical Properties of ZrO_2–Fe_2O_3– Cu Compositions

Composition, percent			Electrical Resistivity, ohm cm	Temperature Coefficient of Resistivity at Room Temperature
ZrO_2	Fe_2O_3	Cu		
20	80	..	3×10^5	Neg
20	80	20	6×10^5	Neg
40	60	..	7×10^5	Neg
40	60	20	3×10^5	Neg
60	40	..	4×10^6	Pos
60	40	20	9×10^4	Neg
80	20	..	8×10^6	Pos
80	20	20	8×10^5	Neg

Table II—Electrical Properties of TiO_2– Ni Compositions

Composition, percent		Heat-Treatment, deg C	Electrical Res. at Room Temp, ohm cm	Temp Coef of Resistivity, 25–200 C
TiO_2	Ni			
100	..	950 in	4.34×10^8	$+1.2 \times 10^8$
80	20	nitrogen	1.63×10^4	$+4.2 \times 10$
100	..	1000 in	1.42×10^8	$+3.1 \times 10^8$
80	20	nitrogen	5.3×10^4	$+7.7$
100	..	1200 in	1.9×10^7	$+4.2 \times 10$
80	20	nitrogen	3.3×10^8	$+1.9$
100	..	1200 in N and	1.2×10^4	-3.2×10^{-1}
80	20	1150 in H	1.1×10	-2.4×10^{-4}

Table III—Melting Points of Metals, Their Oxides and Silicates

Element	Metal, deg C	Oxide, deg C	Silicate or Mixture of Oxide With SiO_2, deg C
Magnesium	651	2,800	1,890
Aluminum	660	2,050	1,810
Zinc	419	1,975	1,510
Titanium	1,800	1,825	1,540
Zirconium	1,900	2,690	2,430
Barium	850	1,925	1,700
Strontium	800	2,430	1,580
Calcium	810	2,570	2,130
Chromium	1,615	3,000	.....
Nickel	1,455	1,990	1,725
Cobalt	1,480	1,935	1,725
Beryllium	1,350	2,530	2,000
Cerium	640	2,600	.....

in compressive strength, but they withstand high temperatures without corrosion.

Research is at present being conducted to develop techniques for mixing both metal powders and ceramic materials, then compacting and heat-treating the mixture to combine the high strength of the metals with the non-corrosive quality of the ceramic products.

The problems of high temperature resisting materials can also be solved by developing multiple layer materials, for example a metal layer covered by ceramic layers. The metal layer to give high strength and the ceramic layers to furnish corrosion resistance.

The problems, however, start with the sintering process. The following conditions must prevail for sintering two or more layers of different materials:

1. A chemical reaction between the surface of the metal and the surface of the nonmetallic particles.

2. Final total shrinkage, and shrinkage in every single phase as a function of temperature over the complete range from room to sintering temperature, must be similar for the metal and the nonmetal layers.

3. The thermal expansion coefficient of the sintered product must be the same for all layers.

Multi-layer materials are not only of importance for the development of high temperature resisting materials but also for the development of some electrical parts.

Evaluating Research Workers

From "Critical Requirements for Research Personnel," by the American Institute for Research, Pittsburgh, Pa., March, 1949.

THIS REPORT is part of a research project on the recruitment and training of scientific personnel for the Office of Naval Research. Heretofore there has been no systematic study of the activity and products of the research worker on his job. This report embodies all the data collected through a study of some 500 research workers. The data were collected by observers who were experienced research workers in responsible positions. These leaders of active scientific and engineering groups submitted objective reports on the activities of research workers on the job. Evaluations of the observed activities were made on the spot. These evaluations included only two types of judgment: First, that the specific activity was of real importance to the job; second, that it was done so well or so poorly as to warrant special notice. Some 2,500 critical incidents were collected and analyzed to provide the list of critical requirements in terms of behavior for research workers. Main areas of the critical requirements were as follows:

I. Formulating Problems and Hypotheses—including identifying and exploring problems, defining the problem, and setting up hypotheses.

II. Planning and Designing the Investigation—including collecting background information, setting up assumptions, identifying and controlling important variables, developing systematic and inclusive plans, developing plans for the use of equipment, materials, or techniques, anticipating difficulties, determining the number of observations.

III. Conducting the Investigation—including developing methods, materials, or equipment, applying methods and techniques, modifying planned procedures, applying theory, attending to and checking details, analyzing the data.

IV. Interpreting Research Results—including evaluating findings and pointing out implications of data

V. Preparing Reports — including describing and illustrating work, substantiating procedures and findings, organizing the report, using appropriate style in presenting report.

VI. Administering Research Projects —including selecting and training personnel, dealing with subordinates, planning and coordinating the work of groups, making administrative decisions, working with other groups.

VII. Accepting Organization Responsibility — including performing own work, assisting in the work of others, subordinating personal interests, accepting regulations and supervision.

VIII. Accepting Personal Responsibility—including adapting to associates, adapting to job demands, meeting personal committments, being fair and ethical, showing interest in work.

In each of these categories, behavior incidents were classified as being effective or ineffective. These behaviors were then consolidated as a series of fundamental actions, which are then arranged to form a check list. It is intended that this check list will be used for evaluating the effectiveness of on-the-job performance of scientific personnel. The term "scientific personnel" is intended to include basic research, applied research, design, development, production engineering,

Table I—A Portion of the Checklist for Evaluating the Performance of Scientific Personnel

Ineffective	Effective
A. Identifying and Exploring Problems	
1) Failed to investigate chance findings or comments suggesting a new problem.	1) Investigated chance findings of comments suggesting a new problem.
2) Failed to investigate unexpected results or difficulties encountered in work.	2) Investigated completely unexpected results or difficulties encountered in work.
3) Worked on a problem which had already been solved or proved unproductive.	3) Chose for investigation a problem for which solution was urgently needed.
4) Allowed a successful technique to be dropped without further application to new problems.	4) Suggested a new problem which could be studied with an already successful technique.
5) Overlooked a problem in current work needing further research.	5) Proposed an entirely new problem or line of research.
	6) Suggested that a previously unsolved problem could be studied with methods or materials recently made available.
	7) Conducted preliminary investigations to see whether phenomena merited experimental as well as theoretical study.
	8) Conducted preliminary investigation to furnish basic data essential to work on a practical problem.
	9) Applied material from a current course of study to problem.

testing, evaluation and administration of research programs.

A portion of the check list relating to sections or Category I is given in Table I. (The reader will probably note that Item 3 under "Ineffective" contradicts Item 6 under "Effective". Furthermore, it is not true that either of these behaviors are ineffective or effective per se. The editors have contacted the American Institute for Research and are advised that an instruction manual on the use of these check lists has been prepared and should be followed when using the check list.)

The 2,500-some incidents were then formulated and grouped into organized lists of behaviors. Studies then were made to find out whether different kinds of classifiable behaviors were especially applicable to specific jobs. A statistical analysis was made, and the report gives charts showing the percent of various behaviors.

A summary of these findings is that the differences found chiefly relate to the importance of administrative behaviors for certain professional grades, and for certain scientific functions. There was some relationship in age, experience and education, but on the whole it was concluded that the evaluation charts can be applied without serious modification to a wide variety of scientific and engineering jobs. Further study is planned.

Frictional Properties of Lead-Base and Tin-Base Bearing Alloys

Foreign Abstract from "The Frictional Properties of Lead-Base and Tin-Base Bearing Alloys", D. Tabor, *Bulletin No.* 212, Council for Scientific and Industrial Research, Commonwealth of Australia, Melbourne.

THIS PAPER DESCRIBES WORK on tin-base and lead-base bearing alloys that possess soft matrices in which are dispersed small hard particles, and also on special alloys consisting of the matrix material alone.

Measurement of friction at room and elevated temperatures for clean and for lubricated surfaces showed that the hard particles of the bearing alloys played no great part in the basic frictional and wear properties of the alloys. The view is put forward that the frictional behavior of a white-metal bearing alloy is a function of the properties of the matrix, although under service conditions there may be other properties that determine the suitability of the alloy for use in bearings.

The Bulletin describes experiments with a typical tin-base and a lead-base bearing alloy. There frictional behavior was investigated at room temperature and at elevated temperatures, in the presence and in the absence of lubricant. To obtain evidence on the respective roles of the matrix and the hard crystallites, special matrix alloys were prepared, consisting of the matrix material only, and their properties compared with those of the bearing alloys. It should be emphasized that these matrix alloys were only approximations to the complex phase relationships existing in their respective alloys. Frictional measurements were also made using pure lead and pure tin.

Each combination was tested in two ways: First with one metal as the upper curved surface, and then with metals interchanged. In the experiments the speed of sliding varied from

Table I—Hardness Values of Metals Tested

Material	Microscopic Hardness, Vickers	Microhardness in Equivalent Vickers Units
Pure lead	4	
Lead bearing alloy	21	Matrix 19 Cuboids 110
Lead matrix alloy	18	Lead-rich solid solution 18 Duplex Pb-Sn-Sb eutectic 18
Steel	166	
Pure tin	7	7
Tin bearing alloy	24	Matrix, about 20 Needles, greater than 100
Tin matrix alloy	18	18

Table II—Friction of Steel, Lead, and Lead Alloys

Surface	Unlubricated			Lubricated		
	μ, max	μ, mean	Motion	μ, max	μ, mean	Motion
Steel on lead	0.9–1.0	0.9–1.0	Fairly smooth	0.5	0.3	Large stick-slips
Steel on lead bearing alloy	0.4–0.45	0.35	Small stick-slips	0.12	0.12	Smooth
Steel on lead matrix alloy	0.35–0.4	0.35–0.4	Smooth	0.14	0.14	Smooth
Lead on steel	0.9	0.5	Large stick-slips	0.4	0.22	Large stick-slips
Lead bearing alloy on steel	0.5–0.55	0.35–0.4	Stick-slips	0.32	0.18	Large stick-slips
Lead matrix alloy on steel	0.65–0.7	0.4	Large stick-slips	0.35	0.2	Large stick-slips

Table III—Friction of Steel, Tin, and Tin-Base Alloys

Surface	Unlubricated			Lubricated		
	μ, max	μ mean	Motion	μ, max	μ, mean	Motion
Steel on tin	0.9	0.6	Large stick-slips	0.6	0.35	Large stick-slips
Steel on tin bearing alloy	0.7	0.45	Large stick-slips	0.13	0.13	Smooth
Steel on tin matrix alloy	0.8	0.45	Large stick-slips	0.13	0.13	Smooth
Tin on steel	0.8	0.5	Large stick-slips	0.36	0.17	Large stick-slips
Tin bearing alloy on steel	0.7	0.4	Large stick-slips	0.35	0.16	Large stick-slips
Tin matrix alloy on steel	0.8	0.4	Large stick-slips	0.4	0.2	Large stick-slips

0.01 to a few centimeters per second, so that the surface temperature of the metals was sensibly the same as their bulk temperature.

The lead-base alloy investigated had the following composition: Sb, 15.0 percent; Cu, 0.5 percent; Sn, 6.0 percent; and Pb, 78.5 percent. Photomicrographs showed a microstructure consisting of a lead-tin-antimony eutectic, in which are dispersed the hard cuboids of tin-antimony compound.

The matrix alloy, with which the lead bearing alloy was compared possessed the following composition: Sb, 10 percent; Pb, 87 percent, Sn 3 percent; and Cu, 0 percent. The microstructure consisted of dendrites of lead-rich solid solution set in a duplex matrix of lead-tin-antimony eutectic. No hard particles were present, and the structure approximated that of the matrix material of the lead alloy.

In Table I the hardness values of the metals used are summarized. Table II gives the frictional results using unlubricated surfaces and lubricated surfaces. The lubricant used was a refined mineral oil, and was applied as a thin smear.

The tin-base alloy investigated had the following composition: Sb, 6.5 percent; Cu 4.2 percent; Sn, 89.2 percent; and Ni, 0.1 percent. Its mean hardness was 24 Vickers. The microstructure consisted of a matrix of a tin-rich solid solution, in which are embedded numerous hard needles of copper-tin compound. This alloy was compared with pure tin, and also with a tin-base matrix alloy containing: Sb, 7 percent; Ni, 0 percent; and Cu, less than 0.4 percent. Table I gives hardness values of these materials. In Table III are given the frictional results using unlubricated surfaces and lubricated surfaces. The same mineral oil was used as with the lead-base alloys.

The results discussed in this Bulletin support the view that the friction between metal surfaces results primarily from the shearing of metallic junctions formed at points of contact, and to the force required to drag the surface irregularities of the harder surface through the softer one. When the plowing term is small, the friction is determined by the real area of contact and the shear strength of the junctions.

For clean surfaces, where the adhesion between the metals is good, the shearing usually takes place within the softer metal and the friction depends upon the shear strength of the softer metal itself.

When the surfaces are contaminated, either with oxide films or lubricants, the total area of contact is essentially unchanged; but the amount of metallic contact is reduced and the strength of the junctions diminished.

With clean metal surfaces, as a rule, it is not possible to reduce the friction by using a metal of low shear strength, since such a metal is usually soft and gives a comparatively large area of contact. A small value of shear strength and area of contact, however, may be achieved by depositing a thin film of a soft metal on a hard one. The hard surface supports the load, giving a small area of contact, while the shearing takes place within the thin film of the metal of low shear strength.

Nickel Alloy Steel Castings

Foreign abstract from "Nickel Alloy Steel Castings to British Standard Specifications No. 1458 and 1459", *The Nickel Bulletin*, Vol. 22, No. 5, published by The Mond Nickel Company, Ltd., Sunderland House, London.

THE ARTICLE DISCUSSES the selection of steels to meet the new British Standards Specifications No. 1458 and 1459 covering alloy steel castings for structural and general engineering purposes. Table I gives the mechanical property requirements of these two specifications.

Scope and potentialities of alloy steel castings in engineering applications are briefly reviewed. The specific requirements of these British Standard Specifications as they affect foundrymen and designers are discussed. Typical nickel alloy steel compositions for meeting these requirements are described.

The specifications cover hardened and tempered castings in accordance with the generally accepted metallurgical principle that to obtain the best combination of strength, ductility and toughness, alloy steels should be in the hardened condition. Dependence on such heat-treatments for the attainment of specification properties demands, however, that careful consideration be given to the factors influencing heat-treatment response such as steel composition, mass effect, and severity of quenching or hardening treatment applied.

Table I—Mechanical Properties of Alloy Steel Castings

Mechanical Properties	British Standard Specification No.	
	1458	1459
Ultimate Tensile Stress, tons per sq in.		
not less than	45	55
not more than	55	65
Yield Stress or 0.5 percent proof stress, tons per sq in.		
not less than	32	38
Elongation, percent not less than	15	12
Reduction in area, percent not less than	30	25
Izod impact value, ft lb not less than	25	15
Brinell hardness number.	201–255	248–302

In Table II are given compositions of nickel alloy steel castings suitable for meeting the new specifications. These compositions cover a range of steels of increasing hardenability. They have been selected to meet the requirements of section thickness, heat-treatment, and mechanical properties demanded. In Table III are given alloy steels appropriate for maximum sectional thicknesses and hardening treatment either by air cooling or oil or water quenching. For complicated castings or castings of varying section thickness, water quenching is seldom applicable, therefore, oil quenching or air cooling is used with a steel composition of greater hardenability.

In selecting these compositions attention was given to the generally accepted principle of steel heat-treatment, that for the best combination of strength, ductility and toughness hardening should be complete throughout the mass of the component. Also, hardening should be sufficiently intense to permit subsequent tempering treatments at as high a temperature as possible consistent with the attainment of the required yield and tensile strengths.

A high tempering temperature is particularly desirable for high ductility and toughness, and for complete removal of internal stresses arising from hardening or from quenching dissimilar section thicknesses.

To facilitate rectification of castings by welding, the carbon content has been maintained as low as possible consistent with the attainment of adequate hardenability. Carbon is probably the element that contributes most to difficulties in welding.

Table II—Compositions Suitable for Meeting the Requirements of British Standard Specifications Nos. 1458 and 1459

Steel Type	Composition*, percent						Particular Characteristics
	C	Si, max	Mn	Ni	Cr	Others	
1% Nickel	0.25/0.35	0.6	0.5/1.0	0.75/1.25	.....	.....	A low alloy steel for light sections. Excellent fluidity in the foundry and showing good ductility and toughness with medium tensile properties.
1½% Nickel Vanadium	0.25/0.35	0.6	0.5/1.0	1.5/1.75	.....	V 0.08/0.15	Low alloy content steel showing particularly high yield/ultimate strength ratio combined with excellent ductility and toughness. With low carbon excellent for welding application.
3% Nickel	0.25/0.35	0.6	0.5/0.75	2.75/3.25	0.3 max	.....	A highly ductile and tough steel particularly resistant to shock and impact stresses at normal and sub-atmospheric temperatures. With 2% nickel and carbon 0.20 max used for sub-zero applications down to — 75 and with 3% nickel down to — 150 F.
1½% Nickel Molybdenum	0.25/0.35	0.6	0.5/0.75	1.3/1.8	0.3 max	Mo 0.20/0.40	A general purpose low alloy steel offering an attractive range of medium high strength with ductility and toughness. Low carbon variants used for case hardening application and welding. It is also claimed that this steel is particularly resistant to heat 'checking' or 'spalling' under conditions of localized overheating.
Low Nickel Chromium Molybdenum	0.30/0.40	0.6	0.5/0.75	0.75/1.0	0.5/0.8	Mo 0.15/0.25	An economic low alloy steel of good hardenability for medium sections. Capable of heat-treatment to provide a wide range of mechanical properties. Widely used for differential hardening.
1½% Nickel Chromium Molybdenum	0.30/0.40	0.6	0.5/0.75	1.30/1.80	0.9/1.4	Mo 0.25/0.40	A medium alloy steel particularly suitable for medium and heavy sections demanding high strength with ductility and toughness. With higher carbon used for wear-and abrasion resisting applications.
2½% Nickel	0.30/0.40	0.6	0.5/0.75	2.3/2.8	0.75/1.0	Mo 0.35/0.65	An air hardening composition particularly suited for medium heavy sections. With higher carbon content extensively used for wear-and abrasion-resisting applications.
3½% Nickel Chromium Molybdenum	0.30/0.40	0.6	0.5/0.75	3.0/4.5	0.75/1.50	Mo 0.30/0.65	An air hardening composition particularly suited for heaviest sections. Where carbon content is at top limit, also suited for wear-and abrasion-resisting applications.

*Sulphur and Phosphorus contents each 0.05% max.

Table III—Recommended Nickel Alloy Steel Casting Compositions

Specification No.	Condition	Maximum Section Thickness of Castings, in.			
		Under 1½	1½–2½	2½–4	4–6
1458	Water quenched and tempered	1% Ni	1½% Ni-V, 1% Ni	3% Ni, 1½% Ni-V	1½% Ni-Mo, 3% Ni
1459		1½% Ni-V	3% Ni, 1½% Ni-V	1½% Ni-Mo 3% Ni	Low, Ni-Cr-Mo, 1½% Ni-Mo
1458	Oil quenched and tempered	1½% Ni-V, 1% Ni	3% Ni, 1½% Ni-V	1½% Ni-Mo, 3% Ni	Low, Ni-Cr-Mo, 1½% Ni-Mo
1459		3% Ni	1½% Ni-Mo	Low, Ni-Cr-Mo	1½% Ni-Cr-Mo
1458	Air-cooled (or normalized) and tempered	Low, Ni-Cr-Mo, 1½% Ni-Mo	1½% Ni-Cr-Mo, Low, Ni-Cr-Mo	2½% Ni-Cr-Mo 1½% Ni-Cr-Mo	3½% Ni-Cr-Mo 2½% Ni-Cr-Mo
1459		1½% Ni-Cr-Mo, Low, Ni-Cr-Mo	2½% Ni-Cr-Mo, 1½% Ni-Cr-Mo	3½% Ni-Cr-Mo, 2½% Ni-Cr	3½% Ni-Cr-Mo

TECHNICAL NEWS

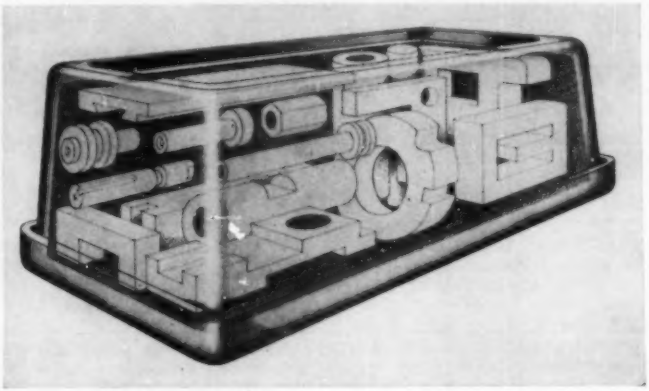
Alloying Process Produces Low-Cost Chromium Case

BOTH HIGH AND LOW carbon steels as well as cast iron can now be made highly wear, heat and corrosion resistant by an English process called Chromalloying. Cost of treating parts averages about six cents a pound, a figure significantly lower than that for chrome plating.

The process is similar to conventional pack carburizing, which consists of placing parts in a carburizing box containing a chrome-rich powder and heating the sealed box in an ordinary open flame furnace for approximately six hours. Temperatures vary from 1,700 to 1,800 F for cast iron and from 1,900 to 2,000 F for various grades of steel. Penetrations not exceeding 0.005 in. are obtainable for high carbon steels and 0.015 in. for low carbon steels. After this treatment, the surfaces of the diffused metal contain as much as 50 percent chrome with an average of 15 percent chrome content at full case depth.

According to metallurgical standards, the surface alloy falls within the category of high chromium steels and is therefore resistant to corrosion and scaling. Thus, Chromalloyed articles can withstand atmospheric corrosion, and show appreciable resistance to salt-water and nitric acid. In addition, the unusually high chromium content results in excellent heat-resistance for all parts exposed to temperatures up to 1,740 F in highly corrosive atmospheres.

The advantages of Chromalloying are derived from an exchange of atoms between the chrome powder and the steel or iron. Chromium, thus diffused into the steel, becomes an integral part and cannot peel off, as would chromium plating. Not only does chromium penetrate the steel, but the chemical reaction that brings about this effect removes an amount of iron equivalent to that of the deposited chromium so that there is no change in dimensions. This factor is important as it means that the process does not alter the contours of intricate shapes and is, therefore, suitable for threaded parts, such as bolts and nuts. Furthermore, the active compound penetrates the smallest "pores" of the metal's surface, resulting in a smooth polishable finish.



PHANTOM VIEW of carburizing box filled with parts packed in chrome-rich powder. Capacity of open-flame furnace determines maximum size of part that can be treated.

Physical properties of treated parts vary to a large extent according to composition. On steels of carbon content from 0.1 to 0.4 percent, the chromized layer is highly ductile, reasonably soft and readily cold worked. Chromized steel sheets of this low-carbon grade can be bent, riveted, hammered, pressed or stamped with ease and cold rolled to considerable elongation. Comparative tests on samples of SAE 4340 steel (0.4C) showed an untreated specimen to have an elongation of 18.5 percent in 2 in. and a treated specimen to have 17.5 percent in 2 in. On the other hand, cast iron and steel of high carbon content acquire a chromized layer that is less ductile, but very hard and highly resistant to abrasion.

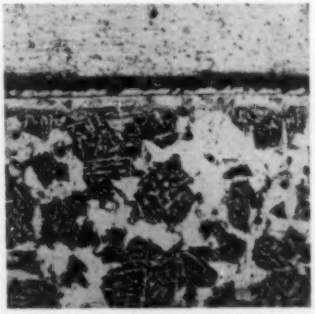
Chromalloying lends itself to economical use on roller chains, especially those subject to extreme atmospheric or highly corrosive conditions. The wear resistant qualities of the chrome case are also desirable for chains that must retain constant pitch over extended periods of service.

In applying the process to non-corrosive applications where chain link hardnesses equal to those of standard steel chains are needed, but where lower-than-standard breaking strengths can be tolerated, changes in steel composition may be required. Coincidentally, slight revisions in dimensional specifications may also be necessary to compensate for thermal expansion.

Adoptation of the process to the malleable and pintle classes of chains is also possible. As with the roller type, attention must be given to the materials and dimensional factors involved.

Hard chrome plating, often used on the pistons in hydraulic cylinder assemblies, can be replaced with a Chromalloy, wear-resistant case, resulting in more economical production and increased life of the piston. The machining operation usually required to bring the piston diameter within tolerances becomes unnecessary, thereby eliminating abrasive chips that are likely to score the metal surface or damage sealing materials. In the same sense, pieces of the hard plating do not appear, since the alloy case does not peel or chip while in service.

Aircraft engine exhaust stacks and



PHOTOMICROGRAPH shows chromized case (black band) on surface of SAE 8640 steel. Magnification: 100X.

manifolds previously made from a costly alloy steel can be assembled from SAE 1020 steel and then chromalloyed. These new units withstand temperatures to 1,200 F without scaling or showing signs of corrosion. Similar substitutions can be made in exhaust system brackets, as well as in the valves of cars, trucks and marine engines. Likewise, many of the decorative components on cars and boats can be chromalloyed. After being buffed, these parts take on a bright finish similar to that of stainless steel or chrome plated surfaces.

Case hardened gears made from medium carbon steel can be chromalloyed and quenched, resulting in improved wear resistance, high tensile strength and satisfactory corrosion resistance. Because of the low friction coefficient of the chrome-rich surface, any tendency for the teeth to gall is significantly reduced. Similar characteristics can be obtained for large gate valves handling crude oil, soap and other corrosive compounds. Stainless steel valves used on tank trucks carrying milk can be replaced with chromalloyed, low-carbon assemblies.

An extensive test program for evaluating the fields of application for Chromalloying is being conducted by Alexandre Berger of The Diffusion Alloys Corp., New York City.

Chart Paper for Recorders "Printed" Electrically

CHART PAPER for use particularly with commercial facsimile telegraphy, but usable in many types of recording instruments, has a coating of electro-sensitive material that is "printed" by an electric current passing to it from a simple wire stylus. In previous facsimile transmission, the record was made photographically by a beam of light on photo-sensitive paper.

The new paper, dubbed Teledeltos, was developed by the Western Union Telegraph Company. The light grey material meets the requirements for facsimile recording by being instantaneous, dry and permanent.

Facsimile is a system, now coming into wider usage, in which an entire printed page, letter, message or photograph is sent by radio waves or through wire connections from a transmitter to distant receivers. In the transmitter, the copy is rapidly scanned by a beam of light that passes over it in successive lines, each close to the one above. The reflected light, changing with the variations in the markings on the surface being scanned, operates a photo-electric cell from which varying electrical energy is constantly emitted.

At the receiving end, the process is in reverse. The electrical energy causes variation in the beam of light from a photo-electric cell. The varying intensity of the light reproduces an exact copy of the original on sensitized paper.

With this new paper, the record made requires no finishing or fixing. The paper is usable for automatic train position recorders, recording chronographs and galvanometers, wave pattern recorders and other instruments.

Plastic Models Simplify Economical Construction Of Spherical Tanks

A NEW METHOD FOR PREDICTING the flow or displacement of metal plates and sheets that are bent, formed or drawn so that plastic flow occurs is proving particularly useful for laying out the specially shaped plates that form spherical tanks.

The process consists of forming the desired object of a suitable plastic material that has been softened by heat and allowed to cool between dies. The piece is then trimmed to the outline required and "relaxed" by heating to the softening point, thereby permitting it to flatten and assume the desired flat shape. Metal pieces cut to this shape and then dished or formed will flow plastically to produce a finished piece of the correct shape.

In applying this plastic model method to the fabrication of spherical tanks, the layout of plates in a repeating pattern has to be based on the faces of one of the five regular polyhedrons. These are the tetrahedron, the hexahedron or cube, the octahedron, the dodecahedron and the icosahedron which has twenty triangular faces.

The icosahedron can be built without scrap loss, since triangles can be alternated and cut from a rectangular plate without waste. Also four adjacent faces of an icosahedron can be flattened to form a parallelogram and five of these parallelograms will form the entire surface of an icosahedron.

These facts suggested that if a spherical shell were formed by five parallelogrammic units, each representing four adjacent triangular faces of the icosahedron expanded to the spherical surface, the layout would be the best from the standpoint of scrap loss.

With the aid of plastic models, the exact shape of five such plates can be determined. These plates can then be cut from one rectangular plate and dished to final contours with remarkably small scrap loss. As the size of the sphere increases, it is necessary to further subdivide the five parallelogrammic units, and designs have been prepared based on subdividing each side into two, three, four and eight subdivisions.

The construction of a 29-ft diameter sphere by this Iconasphere method rather than by the familiar orange-peel technique results in appreciable material and labor savings. The figures: 700 sq ft or 67 percent less scrap, 20 percent fewer joints to be welded and a $2,500 saving in total cost.

This process is applicable to any formed work where plastic flow is involved, as, for example, spherical tanks; wind tunnel flares, nozzles, contraction pieces; hemispherical, elliptical and toroidal tank bottoms; and

PLASTIC TEMPLATES formed in wooden dies aid in predicting correct and economical shape for bent, formed and drawn metal components subject to plastic flow.

other uses involving dished, pressed, drawn or warped plates.

The Pittsburgh-Des Moines Steel Company, in cooperation with the Mellon Institute of Industrial Research, is responsible for this plastic model method.

Improved Nodulizing Alloy Reported as Safer, Cheaper

TWO RECENT ANNOUNCEMENTS, one by the U. S. Navy and the other by Electro Metallurgical Division of Union Carbide & Carbon Company, have provoked renewed interest in the development of nodular cast iron.

Navy research has shown that an alloy containing 8 percent magnesium in a 50 percent ferrosilicon carrier is cheaper than cerium and less hazardous than metallic magnesium.

Another advantage is that the new alloy acts both as a nodulizing and an inoculating agent. Use of other alloys requires a subsequent inoculation treatment with standard graphitizing inoculants to prevent the formation of mottled or white iron and to produce desirable microstructures and mechanical properties.

Holding-power tests were made of treated metal held in a crucible in a gas-fired furnace. No loss of nodulizing power occurred in castings poured 16 min after treatment.

Electro Metallurgical has announced the availability of a magnesium-ferrosilicon alloy. It contains 7 to 10 percent magnesium, 43 percent silicon, and the remainder chiefly iron. Present cost is 15 cents per pound.

Electronic Device Prints Without Type

PRINTING from moveable type may become an obsolete art if a new electronic device for typesetting proves as successful as its initial prototype has been. The machine sets the image of type characters, the end product being a photographic negative or positive instead of the metal slug produced in standard type-setting equipment.

The inventors are two French telephone engineers, Rene A. Higonnet and Louis Moyroud; chief promoter and future builder is Lithomat Corporation of Cambridge, Massachusetts; and financial backer is a new nonprofit organization, Graphic Arts Research Foundation, Inc., which will hold the patents to the device.

Four basic parts perform successive operations: an electric typewriter with standard keyboard, a memory unit, a counter-justifier and a photographic unit. Operating the keyboard actually encodes the characters, which are stored by the memory unit. The justifier takes into account the space required by the characters typed. When the line is completely typed, the operator pushes a key that actuates the counter-justifying unit so the line is flush right and left.

As the next line is typed, the preceding line is scanned and sent to a perforated disk containing the letter or number, each on a separate glass plate. When the proper coded character appears, a beam of light is triggered by a photocell, the light passing through the disk to a photographic film. So accurately are the disk and light synchronized that the characters are precisely spaced on the line.

The developers claim many advantages for the unit over standard methods of composition with moveable type:

• Speed. Experimental model "sets" about 20 newspaper lines per minute, three times the speed of typesetting machines. Operating the unit from tape—as with a teletype—instead of a keyboard would increase this speed.

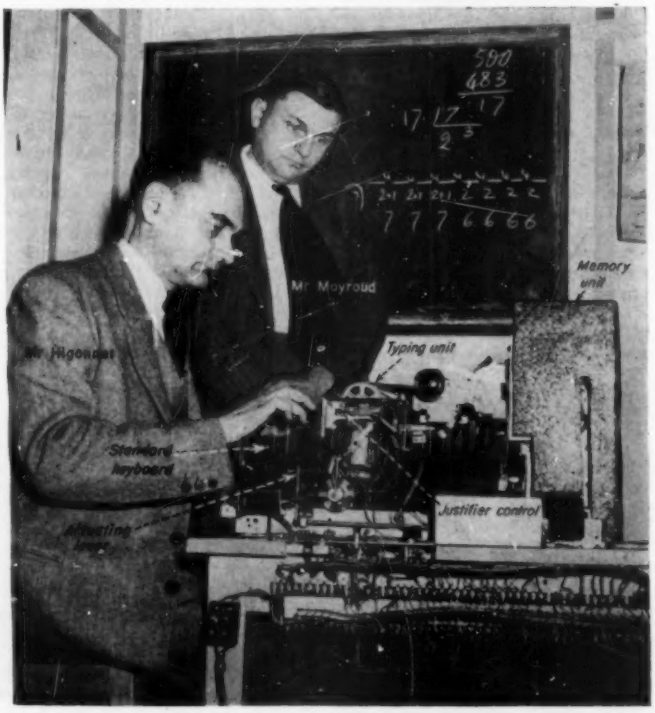
• Versatility. There are no vertical or horizontal limitations as there are to lead type. Characters can be overlapped; tabular matter quickly set.

• Range. A drum will replace the disk in a new machine and will carry 20 fonts of type. Lenses will permit 18 possible type sizes from each font. One operator can thus select from 3,300,000 characters.

• Simplicity. Any electric typewriter can be used. Only settings necessary are type size and length. The operator sees the line before it is photographed, thus reducing errors.

• Clarity. The photographic image is much sharper than a type reproduction. Resulting printing plates will be cleaner.

No one knows what the device will cost. Developers say it will be "inexpensive." They do know, however, that type set by the machine will cost less than that now composed on standard type-setting machines.



PROTOTYPE MODEL of electronic device that may some day take the place of standard lead-slug type setting machines being operated by the inventors.

Washington Notes

Government Halts Flow Of Technical Data to Russia

The Commerce Department has asked the American business community to submit to a plan of voluntary censorship to prevent the flow of advanced technical information to Soviet Russia and its satellites.

Under this plan, persons or companies preparing to export important, though non-secret, American technical data to any foreign country except Canada are requested to obtain approval from the Department's Office of International Trade before transmitting technological information "of an advanced nature significant to the national security."

Canada was made the sole exception because of its close working arrangement with this country on security matters. All other non-Communist countries were included because of the danger that one or more of them might become bases for forwarding information to the Soviet bloc.

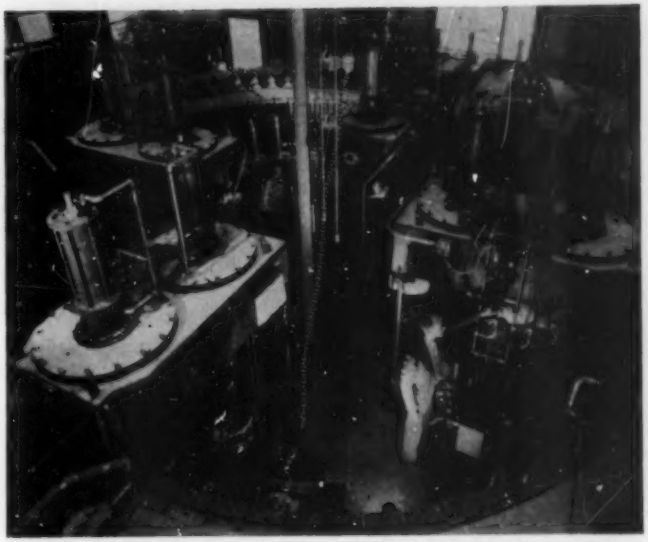
Department officials said the security provisions covered "advanced developments, technology, information and 'know-how' including prototypes (working models), and special installations." The plan also applies to information on such "unclassified items of security significance" as arms, ammunition and implements of war.

It was asked that checks be made with the Patents Commissioner by "patent attorneys and others who contemplate exporting technical data pertaining to patent applications, amendments or information for use in the prosecution thereof, or applications for the registration of a utility model, industrial design or model regarding inventions made in the United States."

Quarter-Scale Bevatron Tops in Atom Smashers

A gigantic machine with a powder-puff nuclear punch has demonstrated for the first time that multi-million dollar cosmic ray atom-smashers being financed by Uncle Sam will deliver the goods. The machine is a quarter-scale model of the 6,000,000,000-v bevatron now under construction at University of California Radiation Laboratory from Atomic Energy Commission funds.

Though only a model and capable of firing protons to only 6,000,000 electron volts, this machine is the biggest atom smasher yet in operation. It has a near-oval magnet and accelerating chamber of 25-foot diameter. The path over which protons travel in one trip around the chamber is 100 ft, by far the longest in atom-smashing history.



WORKING MODEL of 10,000 ton, quarter-scale bevatron at University of California. Ring magnet surrounds eight vacuum pumps attached to four quadrants.

Professor Ernest O. Lawrence reports that the machine operates at an efficiency "equalling our most optimistic advance estimates." The model proves that the revolutionary principles incorporated in the bevatron are practicable. Further experience gained will speed up preliminary work on the full-scale machine by many months. It will also permit starting the machine at 3,500,000,000 electron volts instead of 1,400,000,000 electron volts. The conversion to 6,000,000,000 electron volts will be only one stage further.

The model simulating the conditions of the big machine operates as follows: A ten-ton cyclotron, reminiscent of early ones, acts as the injector, firing 20 bursts of protons a minute into the chamber at three-second intervals. An electrode in the chamber accelerates the protons each time around. As they gain energy, magnet strength is increased to keep them from straying out of their orbit. At the same time, the frequency of the electrode pushes is slowed down to match a slight lagging tendency of the protons at higher energy. During the two-tenths of a second the protons are in the chamber, they make 150,000 trips around the chamber, traveling 10,000 miles. Each burst of protons contains 100,000,000 particles.

The full-scale machine is now being constructed. It will duplicate in the laboratory the cataclysmic atomic disintegrations now achieved only in the medium energy range of cosmic rays. And it will give physicists a better idea of the mysterious force that holds nuclei together.

Supersonic Testing Center To Dwarf Present Facilities

The Air Force has announced plans for an Air Engineering Development Center to be located on the site of World War II's Camp Forest near Chattanooga, Tennessee. The new facility will eventually become the nation's No. 1 supersonic aviation testing center. Its installations will be bigger and more powerful than those in use at the present main air force test base, Wright Field, Dayton, Ohio —or at any of the NACA laboratories.

Already approved for the center is an initial expenditure of $100-million covering an interim-phase financing of three major installations at the 33,000-acre site near Tullahoma—60 miles northwest of Chattanooga.

Two of the three installations are supersonic test equipment captured from Germany at the end of World War II: One is a "hypersonic" wind

tunnel capable of achieving speeds over five times the speed of sound or at least 3,600 mph at sea level conditions. The second is an altitude test chamber for jet and rocket engines, designed for temperatures and atmosphere conditions surpassing any such test equipment in this country. This captured equipment has been expanded and modernized since the war, with the aid of some of the German scientists who originally designed and operated it in Germany.

Third of the main facilities is a supersonic wind tunnel for jet and rocket power plants. The test chamber measures 8 by 8 ft, largest of its kind in this country, and probably in the world.

Key man in the initial program is Maj. Gen. Franklin O. Carroll, brought from his post as director of research and development for the Air Materiel Command at Wright Field.

German Air Compressor Has Promise As Car Engine

An air compressor from a German submarine may develop into a new type automobile or truck engine. Stanford University engineers assert the conversion from propelling torpedoes to powering cars would be simple and the advantage of light weight, lack of vibration and low cost would be appreciable.

The machine is described as being of the "free piston" diesel type that will run on low grade oil. It can take 70 cu ft of free air a minute and compress it to 3,000-psi compressed air. As an engine, it would produce hot gases at a pressure of 100 psi for driving a turbine which, in turn, would drive a shaft.

Tests on this former German U-boat compressor are being made by W. H. Chamberlain, graduate student in engineering at Stanford. The project is aimed at analyzing the thermodynamic and dynamic design aspects of both the air compressor and prime mover types of "free piston" systems.

This type engine was invented by a Frenchman named Rault de Pescara some 20 years ago. He and other scientists in France are still carrying on extensive development work. It is the recent interest in this type of engine, both in France and Germany, that has inspired the American study.

The design of the engine is characterized by extreme mechanical simplicity, according to Professor A. L. London of Stanford. Theoretically, the free piston diesel-turbine prime mover has a higher thermal efficiency than the modern diesel.

Special Magnetometer Developed at NOL

An airborne instrument for continuously recording geomagnetic information from which all magnetic components can be determined has been developed at the Naval Ordnance Laboratory, Silver Spring, Maryland.

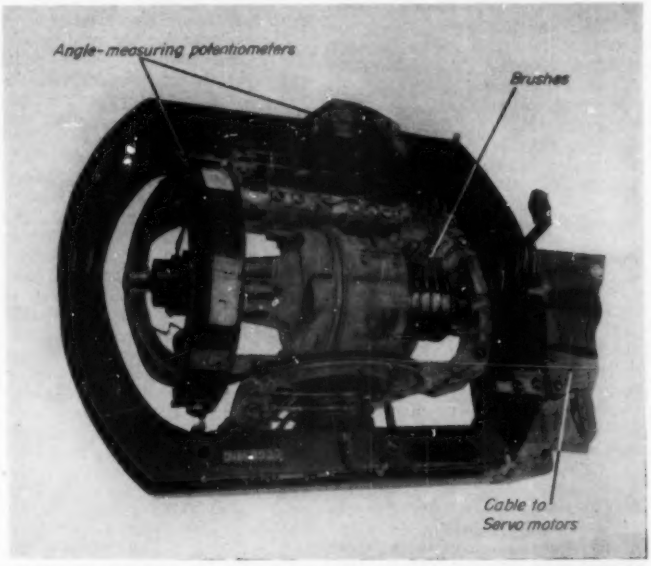
The basic feature of the new magnetometer is its capacity to determine the total magnetic field vector instead of only the intensity. This is done by measuring the intensity and the direction of the total magnetic field vector with respect to a set of coordinate axes stabilized with respect to the surface of the earth.

The sensitive measuring element of the magnetometer is a saturable inductor that is excited by a 1,000-cps current of sufficient amplitude to saturate its Permalloy core. A 2,000-cps voltage is generated by the inductor, the amplitude of which is proportional to the strength of the magnetic field along its axis. The inductor is mounted in a gimbal mechanism driven by servo motors to maintain its detection axis parallel to the earth's magnetic field. The gimbaled arrangement, with its servo motors, is called the detector head and is secured to the frame of the aircraft. Potentiometers and their associated electronic circuits measure the amount of angular displacement of the detection element about the two axes of the gimbals in which the detector is carried. From these angles, the total magnetic field vector can be projected onto a system of coordinate axes fixed with respect to the aircraft.

To make use of these data, the orientation of the aircraft with respect to vertical and true north must be determined. A vertical reference is provided through a gyroscope controlled by gravity-actuated devices that maintain the spin axis of the rotor of the gyroscope vertical. Potentiometers on the roll and pitch axes of the gyroscope measure the inclination of the aircraft with respect to vertical. These angular measurements are used to refer the magnetic data to a coordinate system that is stabilized with respect to the surface of the earth.

During flight the total magnetic field intensity, the aircraft heading, and the angular displacements about the gimbal axes of the detector head and the gyro vertical are continuously recorded by graphic milliammeters. The process of determining the various magnetic quantities from these data is carried out after the flight.

A special system containing an oil-damped pendulum for establishing the vertical inclination of the aircraft was developed. The pendulum will produce true readings only when the aircraft is in a state of non-accelerated flight. The gyroscopes are used to "sense" when the accelerations due to changing altitude are at a minimum.



DETECTOR HEAD of the Navy's improved magnetometer is gimbal-mounted and secured to the frame of airplane. Cable transmits gyroscope movements to servo motors.

Metal Powders Tested As Fuel for Jet Engines

ALUMINUM AND MAGNESIUM powders are being tested for possible use as jet-engine fuels. Announcement of this development was made at the twenty-second Exposition of Chemical Industries in Grand Central Palace, New York City.

Although no jet aircraft have been flown as yet with powdered metals in place of the conventional petroleum fuels, the use of these powders has been the subject of considerable research, both at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, in Cleveland, and within the United States Air Force.

Lieutenant Colonel Norman C. Appold, of the Air Force Propulsion Branch, described these developments involving both aluminum and magnesium, stating that present work centered on heat-release calculations. Present engines would need major modifications as much still has to be determined with respect to the flow of the new fuels through the engine.

New materials on exhibition also included a plasticizer that makes cellulose acetate plastics flame resistant for the first time. An official of Carbide & Carbon Chemicals Corporation explained that cellulose acetate articles will now support combustion when ignited, but that the new form of the plastic will not burn, except when a flame is steadily applied. Hanovia Chemical & Manufacturing Company showed a newly formed substance, a fused quartz crystal intended to replace natural quartz crystals.

Second Design Seminar Scheduled at Lehigh

WIDE INDUSTRIAL ACCEPTANCE of the first product design seminar held last summer at Lehigh University, Bethlehem, Pennsylvania, has led to the planning and announcement of a second seminar in 1950, again in cooperation with the Society of Industrial Designers.

The four-week program—June 26 to July 21, 1950—will offer management personnel from industry a concentrated review of the problems of product design. Discussions with experienced industrial designers and with experts in various kinds of processes and materials will give delegates ample opportunity to become familiar with the current solutions to every type of product design problem.

ALUMINUM TURBINE DISK bursts while under rim loading at 52,000 rpm. Thickness at break in 8-in. diameter tapered wheel is ½ in. Blades are visible at right.

Turbine Disk Analysis Draws Wide Interest

A SYMPOSIUM on gas turbine stress analysis highlighted the annual meeting of the Society for Experimental Stress Analysis held in New York City early last month. More than 170 attended the six technical sessions, which included two papers read by European researchers, one from Austria, the other from Portugal.

The discussions on gas turbines centered around techniques for testing disks. Three Westinghouse engineers described a precision testing machine that handles specimens of 14-in. diameter and 2-in. thickness. Speed can be varied up to 35,000 rpm, the average error being less than 0.01 percent. Specimen temperatures can be controlled at constant levels to 1,500 F or in radial gradients up to 100 F per inch. Plastic and creep strains are measured over the disk surfaces in radial and tangential directions using punch-marked spacings.

Bursting tests of rotating disks were outlined in a paper by W. E. Skidmore, of the Boeing Airplane Company. Investigations of the effects of material, profile, centrally located holes and blade loading indicated that all specimens tested burst at average stresses about 10 percent below material tensile strength. Maximum calculated stresses in disks with central holes were as high as 200 percent of material tensile strength at bursting.

A photographic method for model analysis of structures was presented by two engineers of the Laboratorio de Engenharia Civil, Lisbon, Portugal. Displacements are measured on a special plate on which photographs of the model are taken before and after displacement is developed.

Anti-Friction Bearings Topic of Machine Design Sessions at ASME

FIVE TECHNICAL SESSIONS were conducted by the Machine Design Division at the seventieth annual meeting of the ASME, held in New York November 27 to December 2, 1949. Papers presented were devoted to the selection and application of ball and roller bearings; characteristics of lubericating oils and greases for ball and roller bearings; design of parts for economical production; and flexural fatigue strength of beams.

In speaking to the Division at their second annual luncheon on the subject "Developments in the Machine Tool Industry", Mr. Tell Berna, general manager, National Machine Tool Builders Association, stressed the importance of designing to facilitate loading and unloading work into and out of machines. Such thought on design would increase the productive output of the operator and machine.

This is no idle promise. It is a proved fact, demonstrated day after day in the production of widely varied parts and products. Three tons of N-A-X HIGH-TENSILE are yielding as many finished units as were previously yielded by *four* tons of carbon sheet steel.

This "new arithmetic in steel" is helping scores of manufacturers. They are taking advantage of N-A-X HIGH-TENSILE's greater strength and corrosion-resistance to reduce sections an average of 25%—and still provide greater strength and durability than can be obtained with thicker sections of mild-carbon steel.

At a time when America must make full use of its steel-producing capacities and conserve its natural resources, the trend to N-A-X HIGH-TENSILE has national significance. Each ton produced represents a potential 33% increase in finished goods of superior quality. Investigate the opportunity to make each ton of sheet steel go farther—through the superior quality of N-A-X HIGH-TENSILE.

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • ECORSE • DETROIT 29, MICHIGAN • UNIT OF NATIONAL STEEL CORPORATION

Torque Requirements of Various Motor Driven Loads

G. BYBERG and E. H. FREDRICK
Allis-Chalmers Manufacturing Company

(See p 81-85 for article)

Class of Load	Characteristics	Application	Torque Requirements, percent of Full Load Torque					Max. $*Wk^2$ Ratio (Approx.)	Suitable or Typical Motors
			Locked-Rotor (or Starting)		Pull-in		Normal Pull-out or Breakdown		
			Unloaded	Loaded	Unloaded	Loaded			
1(a)	Start—partially unloaded Breakaway torque—medium Pull-up torque—constant Wk^2—relatively low	Blowers, Positive Displacement	40	—	30	—	140	8	Squirrel Cage Induction or Synchronous
		Edgers	40	—	30	—	250	5	Squirrel Cage Induction or Synchronous
		D-C Generators, Electroplating	40	—	15	—	150	1	Synchronous
		, Cont. Rated	12	—	8	—	150	1	Synchronous or Squirrel Cage Induction
		, 25% OL 2 hours	15	—	10	—	200	1	Synchronous or Squirrel Cage Induction
		Jordans, Paper mill, Plug out	50	—	50	—	150	1	Synchronous or Sq. Cg.
		Pulp Grinders—Magazines	50	—	50	—	140	5	Synchronous
		—3 or 4 pocket	40	—	30	—	140	4	Synchronous
		Metal-Rolling Mills Blooming & Slabbing, 3-high Structural Rail Roughing & Finishing; Plate Mills	35	—	25	—	300	1	Direct Current
		Merchant Mill trains; Billet, Skelp and Sheet Bar mills continuous with lay-shaft; Tube reeling mills	60	—	40	—	250	1	Direct Current, Wound Rotor or Synchronous
		Hot Strip mill Roughing Stand	50	—	40	—	300	1	Synchronous or W. R.
		Tube Piercing; Expanding and Rolling mills	60	—	40	—	350	1	Synchronous
		Saws—Gang	60	—	30	—	200		Squirrel Cage or Synch.
		—Trimmer	40	—	30	—	200	1	Squirrel Cage or Synch.
		Vacuum Pumps (Hytor).....	40	—	60	—	150	4	Squirrel Cage or Synch.
1(b)	Start—partially unloaded Breakaway torque—low Pull-up torque—function of speed Wk^2—relatively low	Centrifugal Type Machines							
		Blowers & Compressors, High-Speed	30	—	60	—	150	15	Squirrel Cage Induction or Synchronous
		Pumps, starting with discharge valve closed—High-speed	40	—	50-60	—	150	1	Squirrel Cage Induction or Synchronous
		—Low-speed	40	—	70-100	—	150	1	Squirrel Cage Induction or Synchronous
		Starting with discharge valve open—	—	40	—	100	150	1	Squirrel Cage or Synchronous
		Pumps—Screw type—started dry	40	—	30	—	150	1	Squirrel Cage or Synch.
		Started primed, disch. open	—	40	—	100	150	1	Squirrel Cage, Synchronous or W. R.
		Pumps—Adjustable blade	50	—	40-75	—	150		Squirrel Cage or Synch.
		Shaker screens	50	—	—	100	150	1	Squirrel Cage or Synch.
1(c)	Start—partially unloaded Breakaway torque—high Pull-up torque—constant average Wk^2—relatively low	Reciprocating Type Machines							
		Compressors							
		Air and gas	40	—	20-30	—	150	10	
		Ammonia, discharge pressure 25 lb per sq in.	40	—	20-30	150	150	7	
		Freon	40	—	40-60	—	150	4	All 1(c) types:
		Carbon Dioxide, Single-cyl., double acting	40-120	—	30-40	—	150	5-10	High Speed; Squirrel Cg. or Synch.
		Carbon Dioxide 2-cylinder, double acting	40-90	—	30-40	—	150	4-7	Low Speed; Synchronous
		Pumps—started dry	40	—	30	—	150	1	
		—by-passed	40	—	40	—	150	1	
		Vacuum Pumps	40	—	60	—	150	10	

(continued on pg 155)

AUTO-LITE *announces...*

Tune in "Suspense!" — CBS Radio Network Thursdays, CBS Television Tuesdays.

The new Auto-Lite plant at Lockland, Ohio, one of the largest manufacturing plants in the world, devotes a part of its 3,500,000 square feet of floor space to precision die casting.

Increased production facilities for

DIE CASTINGS

● Here is important news for everyone who has need of the accurate, reliable die castings made possible with the famous Auto-Lite "controlled metals" processes. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish the high quality die castings for which the Auto-Lite name is known wherever die castings are used. We invite your inquiries.

AUTO-LITE MEANS PRECISION MANUFACTURING

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division, Woodstock, Illinois

600 S. Michigan Avenue, Chicago 5, Illinois
723 New Center Bldg., Detroit 2, Michigan

Torque Requirements of Various Motor Driven Loads (continued)

Class of Load	Characteristics	Application	Torque Requirements, percent of Full Load Torque					Max. $*Wk^2$ Ratio (Approx.)	Suitable or Typical Motors
			Locked-Rotor (or Starting)		Pull-in		Normal Pull-out or Breakdown		
			Unloaded	Loaded	Unloaded	Loaded			
2	Start—must be unloaded Breakaway torque—high Pull-up torque—constant average Wk^2—varies with machine	Attrition Mills	100	—	60	—	175	12	Squirrel Cage, Wound Rotor or Synchronous
		Crushers—B & W	200	—	100	—	250	3	Wound Rotor or High Torque Squirrel Cage
		—Cone Type	100	—	70	—	250	6	Wound Rotor or High Torque Squirrel Cage
		—Gyratory	100	—	70	—	250	4	Wound Rotor Induction
		—Jaw	100	—	70	—	250	2	Wound Rotor Induction
		—Roll	100	—	70	—	250	3	Wound Rotor Induction
		Hammer Mills	120	—	80	—	250	15–40	Wound Rotor Induction
3(a)	Start—partially unloaded Breakaway torque—variable Pull-up torque—variable Wk^2—very high	Attrition Mills	100	—	60	—	175	12	Squirrel Cage, Wound Rotor or Synchronous
		Bandsaw Mills	125	—	30	—	250	100	Synchronous Direct Connected Wound Rotor Belted
		Blowers—Centrifugal	40	—	60	—	150	10–15	Squirrel Cage Induction or Synchronous
		Compressors—Centrifugal	40	—	60	—	150	15–25	Sq. Cg., W. R., Synch.
		—Reciprocating	60–120	—	30	—	150	5–10	Synchronous
		Fans—Centrifugal	40	—	60	—	150	20–50	Squirrel Cage or Synch.
		—Centrifugal (Sintering—with inlet gates closed)	60	—	100	—	150	40–60	Squirrel Cage, Synchronous or W. R.
		Fans—Propeller type, with discharge open	40	—	100	—	150	25	
		Hammer Mills	120	—	80	—	250	15–40	Squirrel Cage, Wound Rotor, Synchronous
		Shredders	50	—	50	—	250	30	Squirrel Cage, Wound Rotor, Synchronous
		Vacuum Pumps (Reciprocating, including sliding vane type)	40	—	60	—	150	10	Squirrel Cage or Synchronous
		Wood Hogs	60	—	30	—	225	30	Sq. Cg., W. R., Synch
4(a)	Start—fully loaded Breakaway torque—high Pull-up torque—high Wk^2—generally low	Ball Mill —Rock	—	150	—	110	150	2	Synchronous
		—Ore	—	160	—	110	150	2	Usually synchronous. Also Wound Rotor
		Bowl Mills—(Coal Pulverizer)	—	150	—	125	150		Squirrel Cage, Wound Rotor, Synchronous
		Beaters-Pulp-Standard	—	125	—	100	150	5	Wound Rotor or Sq. Cg.
		-Breaker	—	125	—	100	200	5	Wound Rotor or Sq. Cg.
		Hydrapulpers	—	125	—	125	150		Synchronous
		Rod Mills-Ore grinding	—	160	—	110	150	1	Wound Rotor or Synch.
		Line Shafts—Flour mills	—	175	—	110	150	15	Synchronous or W. R.
		Reciprocating Pumps—Not by-passed (3-cylinder)	—	150	—	110	150	1	Squirrel Cage or Synchronous
4(b)	Start—unload except in emergency Breakaway torque—high Pull-up torque—high Wk^2—generally low	Rubber Mills—Banbury Mixers	—	125	—	100	250	1	Synchronous or W. R.
		—Plasticators	—	125	—	100	250	1	Synchronous or W. R
		Rolling Mills—Cold-rolling	—	200	—	150	250	1	Direct Current
		Brass and Copper finishing mills	—	150	—	125	250	1	Direct Current
4(c)	Start—cannot be unloaded Breakaway—low Pull-up torque—varies with speed Wk^2—variable	Pumps-Axial-flow with							
		discharge open—		40	—	100	150	1	Squirrel Cage, Wound Rotor, Synchronous
		discharge closed—	—	40	—	200–300	150		Not practicable

If structural weakness or corrosion causes early failure of angles in your machinery or equipment, consider changing to angles made of Armco Stainless Steel.

Corrosion resistance and high strength make Armco Stainless Angles logical wherever structural support is needed in corrosive service. They are ideal for equipment used in the food, chemical, oil, paper, and textile industries, and in similar applications.

Armco Stainless Steel Angles are available for immediate delivery. Write us or call your nearest Armco Distributor. Angle-sizes listed on this page are available in Armco Stainless Steel Types 304 and 316.

Remember too, your Armco Distributor can give you helpful metallurgical assistance and quick delivery of Armco Stainless Steel sheets and bars in all standard types. He can also supply special grades on short notice.

Write us if you are not acquainted with the Armco Distributor in your territory. We're sure you will profit by knowing him. Armco Steel Corporation, 3479 Curtis Street, Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION

Stock Sizes of Armco Stainless Steel Angles

3/4" x 3/4" x 1/8"	1-1/2" x 1-1/2" x 1/8"	2" x 2" x 3/16"
3/4" x 3/4" x 3/16"	1-1/2" x 1-1/2" x 3/16"	2" x 2" x 1/4"
3/4" x 3/4" x 1/4"	1-1/2" x 1-1/2" x 1/4"	2" x 2" x 3/8"
1" x 1" x 1/8"	1-3/4" x 1-3/4" x 1/8"	2-1/2" x 2-1/2" x 3/16"
1" x 1" x 3/16"	1-3/4" x 1-3/4" x 3/16"	2-1/2" x 2-1/2" x 1/4"
1" x 1" x 1/4"	1-3/4" x 1-3/4" x 1/4"	2-1/2" x 2-1/2" x 3/8"
1-1/4" x 1-1/4" x 1/8"		3" x 3" x 3/16"
1-1/4" x 1-1/4" x 3/16"		3" x 3" x 1/4"
1-1/4" x 1-1/4" x 1/4"		3" x 3" x 3/8"

ARMCO

ARMCO STEEL CORPORATION

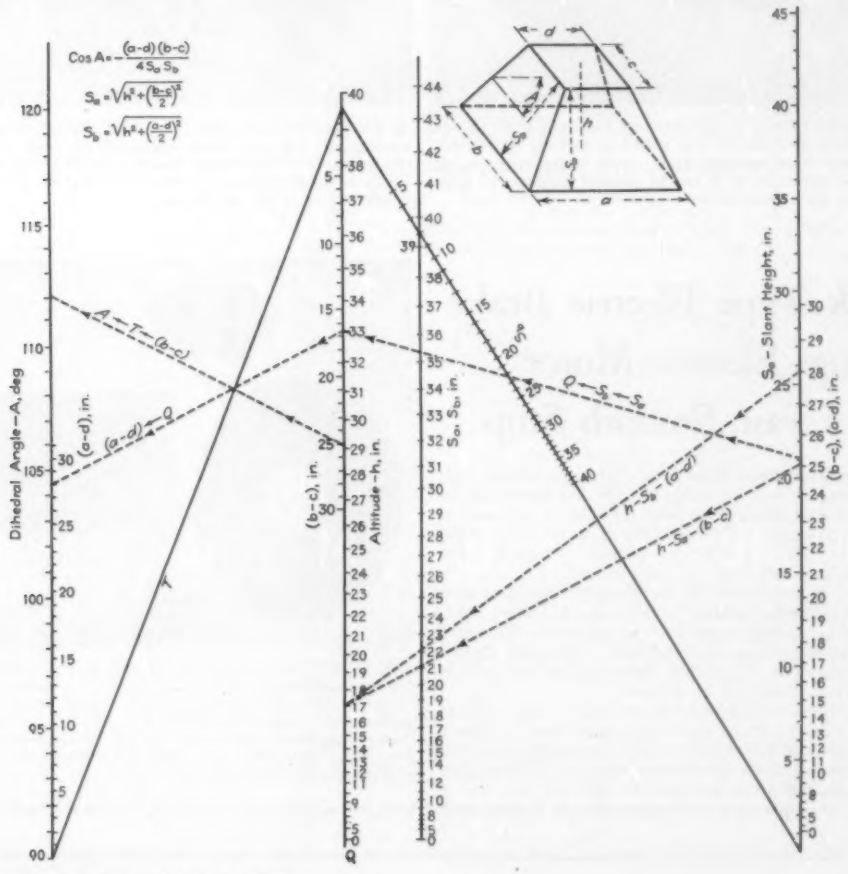
Nomogram for Angles in Constructed Shapes

H. F. BARIFFI

FROM THE ALTITUDE, h, and the differences $(a—d)$ and $(b—c)$ in lengths of corresponding sides of upper and lower bases, the dihedral angle A can be calculated.

To calculate S_b connect the given value of $(a—d)$ on the right hand outer scale with the value of h on the h-scale and read the value of S_b. In like manner, the value of S_a can be calculated from $(b—c)$ and h. Connect the value of S_a to the value of S_b on the diagonal scale and project to the Q-ine. Connect the intersection of this line and the Q-line with the given value of $(a—d)$ on the inner left hand scale. Connect the intersection of this line and the diagonal T-line with the $(b—c)$-scale. Project this line to the left hand scale and read the angle A.

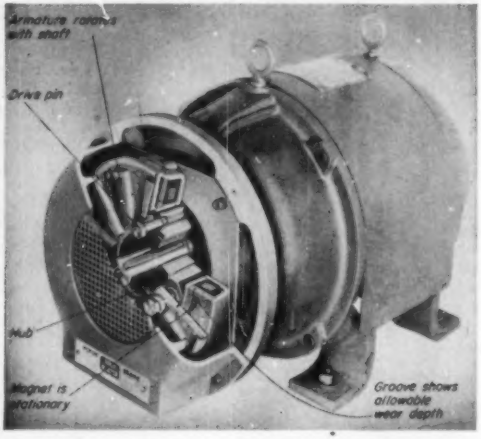
EXAMPLE: When $h = 17$ in., $(b—c) = 25$ in. and $(a—d) = 28$ in., find S_a, S_b and A. Connecting 28 in. on the outer right hand $(a—d)$-scale and 17 in. on the h-scale gives a line crossing the S_b-scale at 22 in. Also, connecting 25 in. on the outer right hand $(b—c)$-scale and 17 in. on the h-scale gives a line crossing the S_a-scale at 21.1 in. A line connecting 21.1 in. on the inner right hand S_a scale with 22 in. on the diagonal S_b scale intersects the Q-line at the indicated point. A line connecting this point with 28 in. on the inner left hand $(a—d)$-scale crosses the diagonal T-line at the indicated point. A line connecting this point with 25 in. on the $(b—c)$-scale passes through the point 112.1 deg on the A scale.



DESIGN DETAILS AND DATA ON

NEW COMPONENTS–

EXTERNAL CONTROL of torque and braking time allows this brake to be incorporated in a system to perform in sequence as a phase of an operating cycle. Since torque output varies with the current input, it can be adjusted manually or automatically (by varying current resistance) to meet the load.



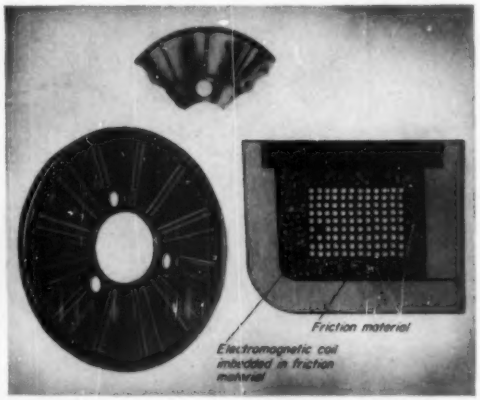
ARMATURE FLOATS freely on its drive pins and compensates automatically for wear. Once assembled, the brake needs no adjustment. Available models mount on NEMA Standard "C" Flange motor end shields for frames 203 through 365. Brake torques run up to 465 foot pounds.

Disk Type Electric Brake Brings Electric Motor To a Fast, Smooth Stop

The two important elements in this electric brake are the electro-magnet and the armature disk. In operation, the armature disk, which turns with the shaft, is attracted to the electro-magnet, which has a friction surface, and remains stationary. Held together by magnetic force, the two elements produce a drag that stops the shaft.

When the magnet is first energized the torque value is very low, allowing backlash in gear trains and other power transmission systems to be taken up gradually. This eliminates the hammering and pounding of solenoid actuated brakes, and allows design from the standpoint of maximum torque loads instead of shock loads.

Since torque output varies with current input, and can be controlled externally, these motor brakes have an infinite torque variation between maximum ratings and zero. This allows control of the deceleration rate as dictated by best design practices, and selection of one unit size for a number of applications of varying torque requirements.



ARMATURE (left) has ribs on the back to give a fan effect. The wear surface (top) is made of segments of magnetic material welded to back plate. Magnet section (right) consists of an electromagnetic design faced with a molded friction material. Power is applied through imbedded coil. Brake requires only 25-35 watts, dc for full application. The company can provide a rectifier for use with 115v, ac power.

Warner Electric Brake Mfg. Co., Beloit, Wis.

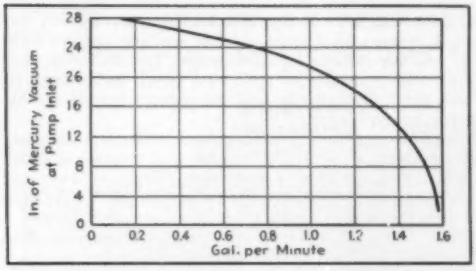
MATERIALS AND PARTS

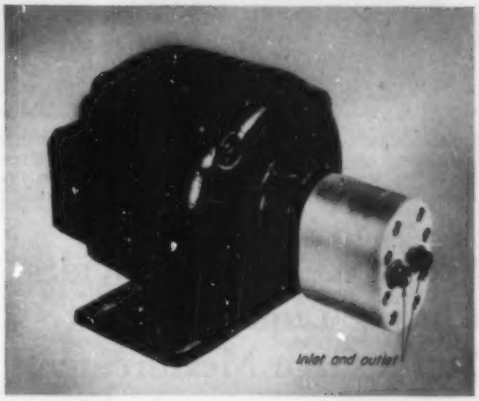
SPECIFIED BY PRODUCT ENGINEERS

Positive Pressure Pump Mounts Directly on Motor

Made specifically for use with quick oil changing equipment, this small gear pump may also be used in any oil pumping application where requirements are not above 1½ gpm at 200 psi. It features a high vacuum of 27 inches of mercury, with a displacement of 0.209 cu. in. per revolution. The pump is connected directly to the end bell of a ¼ hp, 1725 rpm, split phase motor. The pump and motor are usually sold as a unit. Close coupling of the motor and pump give perfect alignment without high material costs, and reduces weight and size to a minimum.

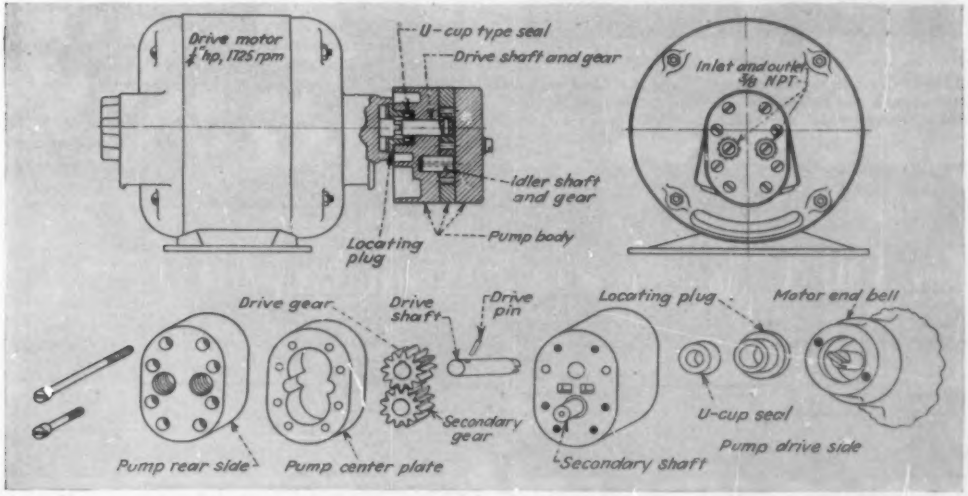
Eastern Industries, Inc., New Haven 6, Conn.





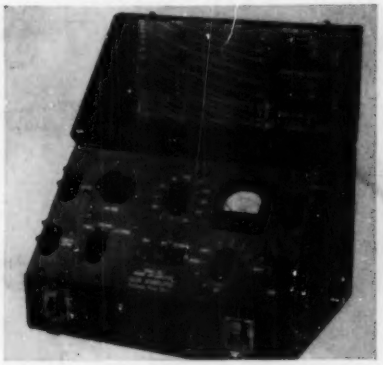
MODEL 1304 gear pump is shown attached to a ¼ hp. motor. The two are usually sold as a unit.

DATA for this efficiency curve is based on S. A. E. 10 oil at 68 deg. F with the pump operating at 1725 rpm.

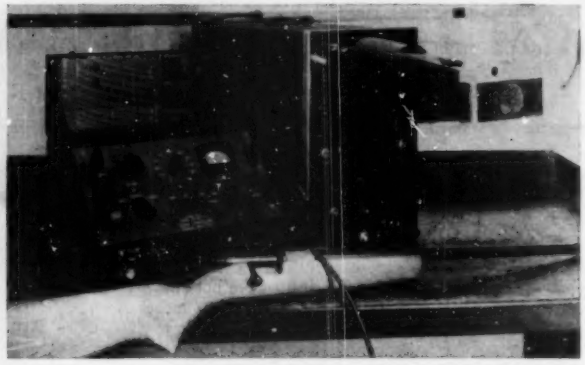


EXPLODED VIEW shows simplicity of construction. The pump body is made of aluminum and the gears of bronze.

CONTINUED ON PAGE 160

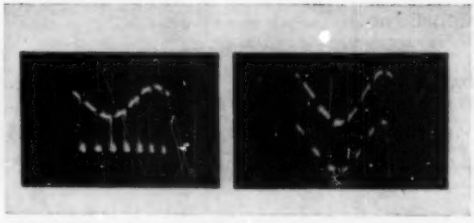


LARGE CHART at top of the set gives readings for all SR-4 strain gages. Calibration is accomplished by chopping one of the ten built-in precision resistors across the active strain gage.



RIFLE CHAMBER expands when cartridge is expanded. Amount of deformation of barrel registers through BA-1, on oscilloscope, and is recorded with camera. Various makes of ammunition may be tested to determine relative explosive force. Strain gages are placed under tape on rifle barrel.

Compact Bridge Provides Missing Link in Strain Gage Measurements



ZERO LINE can be thrown in at will by use of a signal chopper. Calibration is not changed by use of zero line. Two sample photos above show a typical use of the zero line.

Called the BA-1 Bridge and Amplifier, this set fills the gap between a SR-4 strain gage, or similarly actuated pick up, and any cathode ray oscilloscope. Up until now, the stress analyst usually set up a work bench and covered it with the individual electrical components needed for his particular application.

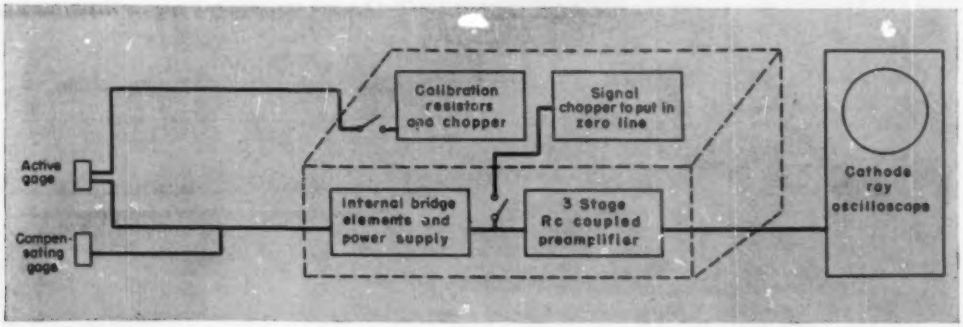
Strain being such a fundamental mechanical reaction, this equipment can give an insight into mechanical problems of function as well as strength. Vibration, damping, displacement, acceleration, pressure, weight, loads, and stresses can be seen during actual operation.

The BA-1 covers a frequency range from static to high frequency, and will handle any frequency needed in stress analysis.

A unique feature is the ability to calibrate while the signal is coming in. Calibration values are read directly from the large chart at top of the unit.

All of these features make the BA-1 an especially handy unit to "take a look around with" in preliminary investigations, as well as an instrument for precise work.

Ellis Associates, Box 77, Pelham 65, N. Y.


Calibration resistors and chopper
Signal chopper to put in zero line
Active gage
Compensating gage
Internal bridge elements and power supply
3 Stage Rc coupled preamplifier
Cathode ray oscilloscope

BLOCK DIAGRAM shows the main component in the system. The two gages shown at left are ordinary SR-4 strain gages. The bridge can be used with any standard cathode ray oscilloscope and will handle any usual frequency range.

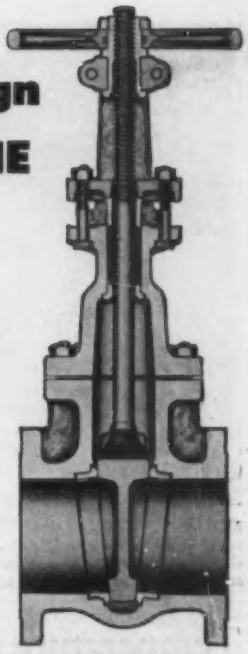
CONTINUED ON PAGE 162

Piping equipment for every design ...from one complete line...CRANE

When you design a **Fuel Oil Pumping and Heating Unit**, for example, your "specs" call for piping equipment that must control steam and heated fuel oil. Actually, however, it makes no difference what fluids you're concerned with . . . or what type of machine you're designing. If it's piping equipment you're after, all you have to do is turn to Crane.

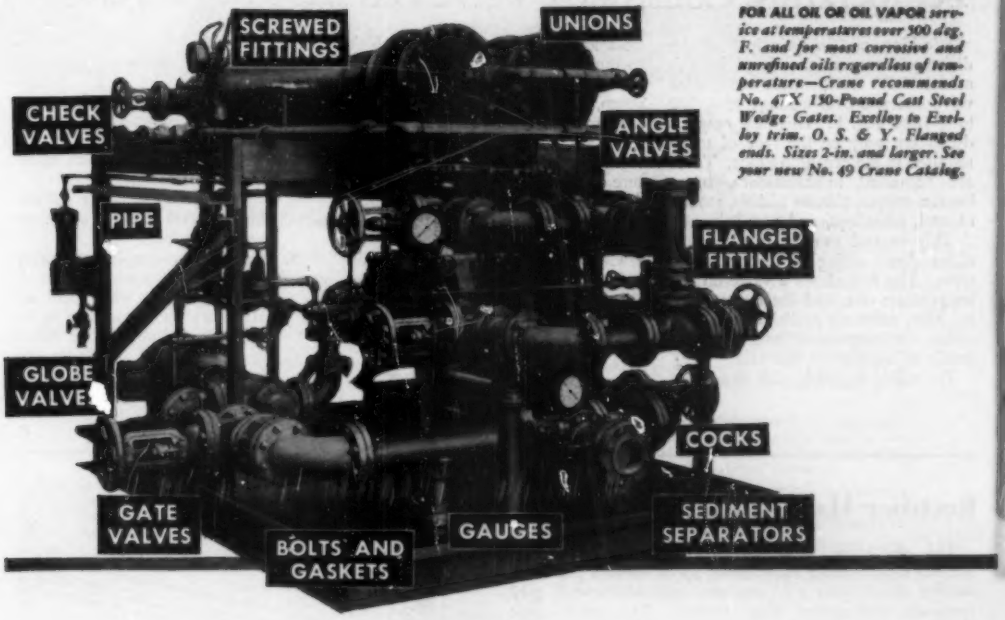
One catalog puts the world's most complete line of piping materials right in the palm of your hand. Specifying Crane as your single source of supply helps to speed and simplify all piping procedures, from drafting room to assembly lines. Also, specifying Crane gives your product added value. Machinery buyers know from experience that Crane Quality cannot be surpassed.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



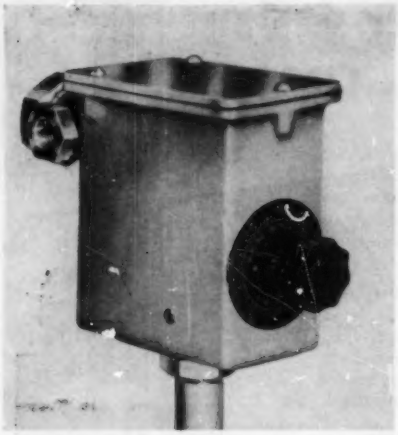
FOR ALL OIL OR OIL VAPOR *service at temperatures over 500 deg. F. and for most corrosive and unrefined oils regardless of temperature—Crane recommends No. 47X 150-Pound Cast Steel Wedge Gates. Exalloy to Exalloy trim. O. S. & Y. Flanged ends. Sizes 2-in. and larger. See your new No. 49 Crane Catalog.*

YOU NAME IT... CRANE SUPPLIES IT
EVERYTHING IN PIPING FOR YOUR DESIGN

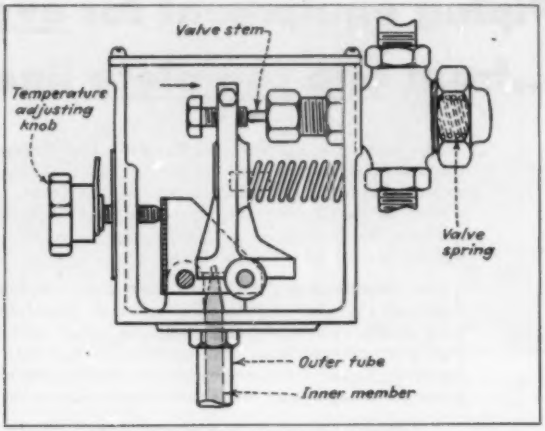


EVERYTHING FOR EVERY PIPING SYSTEM **CRANE**

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING



MODEL "Y" Self Contained Temperature controlled valve works on the principle of the differential expansion of solids. A system of levers multiply this action and open or close the valve as needed.



WHEN TEMPERATURE DROPS, outer tube cools and contracts. This pushes the inner member against a lever which pivots on its bearing and presses the valve stem in. This allows more fuel to enter furnace and raise the temperature. The valve spring then returns the valve.

Temperature Controlled Valve Has 2,100 deg F Range

Working on the principle of the differential expansion of solids, this model "Y" temperature controlled valve operates over a range of —300 to +1800 deg. F. This heat range is dependent only on the type of material used in the expanding tube. Tubes are furnished in aluminum, brass, bronze, copper, chrome nickels, monel, inconel, hastelloys, and pure silver.

This control can be furnished in either direct acting or reverse acting types. The first closes a valve on the temperature rise, and the latter opens it. Also, units are available with provision for temperature settings either inside or outside of the case.

The valves available with these controls are all bronze, and are of the spring-closing type with renewable disks suitable for air, water, gas, oil, steam, or gasoline. Valves now available range from ¼ to ¾ in. in size. There is no backlash or lost motions in the movement of the valve, since pressure on all parts is always in the same direction.

GENERAL APPLICATIONS:

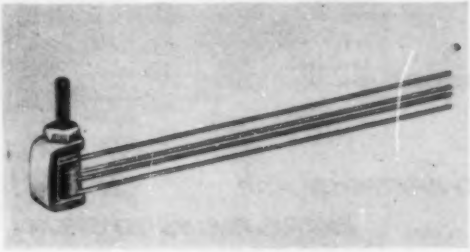
1. Controlling temperature by controlling the flow of fuel:
   (a) Oil or gas-fired furnaces, ovens, etc.
   (b) Oil or gasoline-fired portable equipment.
   (c) Steam heated equipment.
2. Controlling temperature by controlling flow of cooling medium: air conditioning, cold storage, cold cabinets, etc.
3. High temperature safety cut-off: The valves are installed in fuel lines to shut off flow with excessive temperatures.
4. Low temperature safety cut-off: Shuts off fuel when it drops below flash point.
5. High or low temperature safety cut-off for air operated valves: When equipped with small air valves they can be installed in the high pressure air line to either cut-off or bleed air from the diaphragm control valves.

Burling Instrument Co., 253 Springfield Ave., Newark 3, N. J.

Rectifier Has Instrument Uses

This new copper oxide rectifier features a gold-to-gold internal circuit arrangement made up of vacuum processed rectifier plates with gold contacts, specially treated gold terminals, and copper alloy brackets. This construction eliminates many mechanical design difficulties usually found in instrument rectifiers. Model XC 14 is impregnated and sealed to withstand extreme humidity. Factory-set pressure remains constant under wide temperature changes.

Bradley Laboratories, Inc., New Haven, Conn.



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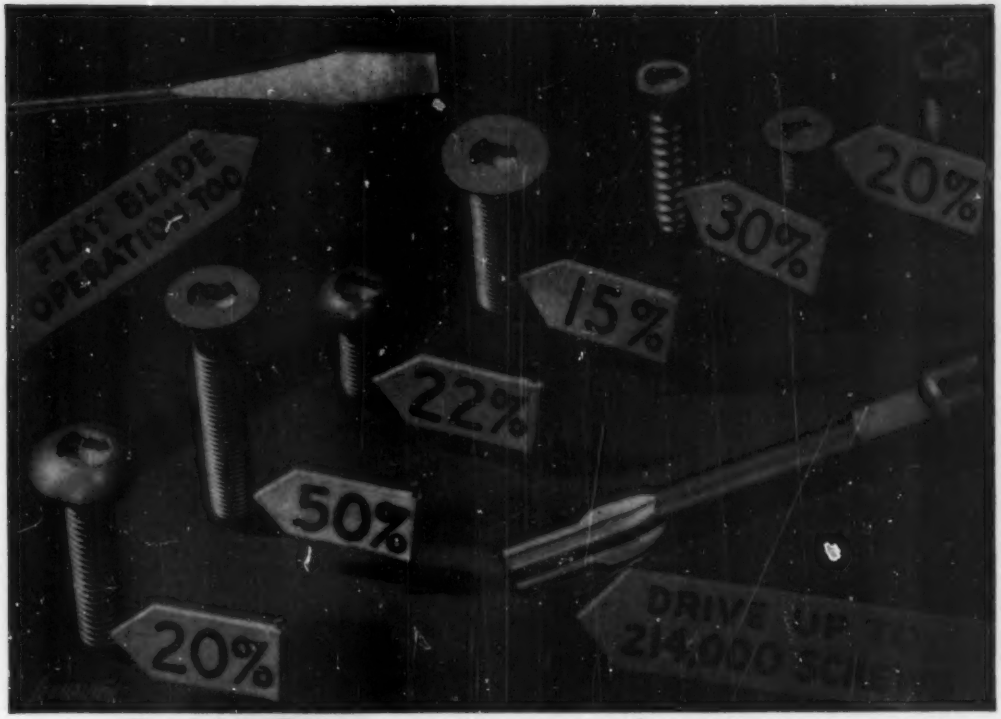


Here's How CLUTCH HEAD *Lowers the Cost of Driving Screws*

These Production Increases Tell the Story

Double-check these exclusive features of "America's Most Modern Screw" and determine what they mean to your assembly line in terms of *lower screw application cost.*

√ ***The smooth speedy tempo of the line*** is unhindered by operator hesitation. High visibility of the roomy Clutch recess inspires confidence with an easy-to-hit target.

√ ***The time toll of burred or chewed-up heads*** is eliminated by CLUTCH HEAD'S non-canting driving action. The Center Pivot column on the Type "A" Bit makes straight driving automatic . . . even with "green" operators.

√ ***Skid damage to men and materials*** is checked out by CLUTCH HEAD'S all-square non-tapered driving contact . . . for definitely *higher non-stop speed,* and with maximum safety.

√ ***With no end pressure to combat "ride-out"*** (as set up by tapered driving) the CLUTCH HEAD drive-home is effortless, disposing of a fatigue factor. No end-of-the-shift lag means more screws driven.

√ ***Rugged Bit drives up to 214,000 screws*** without stop for tool change. Add to this production gain the multiple saving in tool cost . . . because the Type "A" Bit may be repeatedly reconditioned in 60 seconds.

√ ***The Lock-On ousts fumbling fingers*** by uniting screw and bit as a unit for one-handed reaching at any angle into inside spots. This feature frequently dispenses with use of a second operator.

√ ***Basic design for screwdriver operation*** is a boon to service men and users . . . simplifying emergency field adjustments to save valuable operating time.

√ ***Ask us to send you*** package assortment of screws along with sample Type "A" Bit and illustrated Brochure . . . so that you may personally check these features.

CLUTCH HEAD SCREWS

"AMERICA'S MOST MODERN SCREW"

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

Low Power Speed Controller for Shunt or Universal Motors

This new model 1701-A is similar in design to previous models of the "Variac" speed control, but is of smaller size. It controls either a 1/20 hp, dc shunt motor, or a 1/15 hp universal motor directly from an ac line. The range of continuous speed variation available is from motor rated speed down to nearly zero, at constant torque. The motor can be reversed almost instantly by flipping the forward-reverse switch. No time delay is necessary for starting or reversing.

Two models of the Type 1701-A Variac Speed Control are available: Type 1701-AK, for operating a 1/20 hp, dc shunt motor, and Type 1701-AU, for operating a 1/15 hp universal motor. On the shunt motor model, two speed ranges are provided—one with a maximum speed corresponding to twice rated speed.

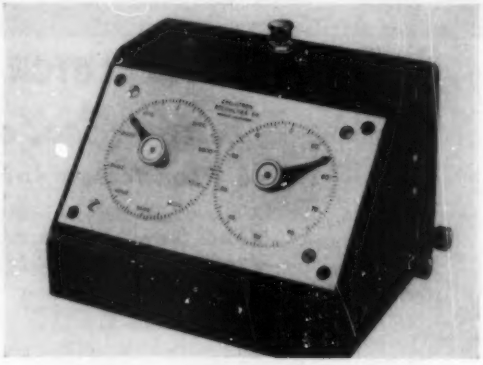
The universal motor model provides a single speed range, because universal motors in general are available in higher speed ranges. To operate the universal motor from the Type 1701-AU Variac Speed Control, separate leads must be brought out for the armature and the field. Since the field voltage is held constant, the operating characteristics are those of a shunt motor rather than a series motor.

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Impulse Register Counts Mechanical Cycles

Called the Cyclo-Trol Register, this instrument has two calibrated dials that can be set for any number from 0 to 10,000. Upon reaching the set number of counts, the instrument stops the machine, and can instantly be reset for another operation. Among many other applications, the Cyclo-Trol register is ideal for coil winding machines. The exact number of turns can be preset and the machine stopped at any point, making possible any number of identical coils. The counting rate is as high as 60 impulses per second, power source is 115v, ac, and the output circuit 50v, dc. This output circuit may be either direct or to an auxiliary relay.

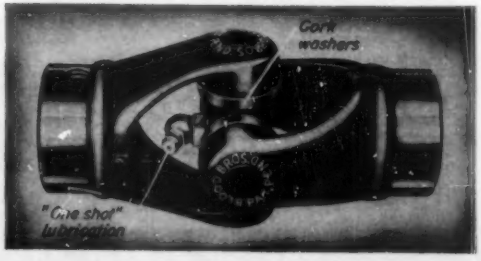
Cyclotron Specialties Co., Moraga 5, Calif.



Universal Joint Has Sealed Parts

Called the K2R, this small universal joint has fully sealed working parts and "one shot" lubrication. Specifically designed for severe operating conditions and dusty applications, the K2R is an improvement on the company's K1C joint. It is to be used with dump bodies, road graders, and various agricultural applications. Cork washers and retainers on each of the four trunnion bearings seal in lubrication and keep out dirt.

Blood Brothers Machine Co., Allegan, Mich.



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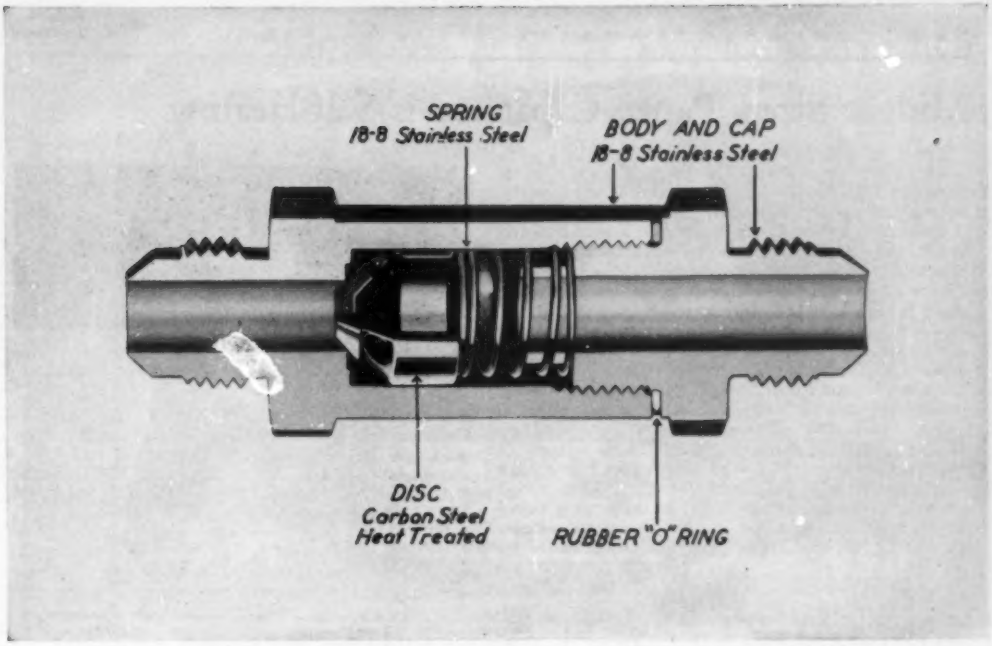


Specify KOHLER precision made CHECK VALVES for long service

Send for illustrated catalog

Kohler Co., Dept. 22-U, Kohler, Wisconsin
Please send me, without obligation, your Precision Parts Catalog.

Name_____

Title_____

Company_____

Address_____

Kohler Cone Type Check Valve, K-1249, is a high pressure valve increasingly specified for hydraulic fluids, gasolines, oils, water and acids non-corrosive to stainless steel. It has an operating pressure up to 3000 PSI, and a burst pressure of 7500 PSI. The metal-to-metal seat in this valve is best suited for high pressures, extreme temperatures and corrosive fluids. Available in sizes ¼", 5/16", ⅜", ½" and ⅝". Larger sizes and combinations of connections can be furnished to your requirements.

Uniform excellence of results obtained with Kohler Precision Parts has steadily increased the demand, by leading manufacturers, for Kohler valves and other parts for all types of industrial, aircraft and automotive installations. Kohler maintains complete facilities, in one plant under unified supervision, for forging, sandcasting, tooling, machining, finishing, assembling, testing and inspecting. This assures efficient service and prompt deliveries, as well as high standards of manufacturing. Please feel free to call on Kohler engineers for cooperation in developing any parts you need for special applications.

KOHLER OF KOHLER

PLUMBING FIXTURES · HEATING EQUIPMENT · ELECTRIC PLANTS · AIR-COOLED ENGINES

Midget Sized Paper Capacitor is Self-Healing

These three basic types of small paper capacitors are from ¼ to ⅓ the size and weight of conventional paper and foil designs, and have a unique "self-healing" ability.

Both the reduction in size and the "self-healing" effect result from the development of a practical method of continuously coating capacitor paper with a thin conducting film of metal about four millionths of an inch thick. The metal is applied to the paper by the evaporation process. In this process both paper and coating metal are placed in a high vacuum. The metal is then heated until its vapor pressure is above that of the surrounding pressure in the chamber. The metal then gives off a vapor which condenses on the comparatively cool surface of the paper.

The "self-healing" effect overcomes the major weakness of conventional paper foil capacitors. Excess voltages do not produce short circuits in these capacitors even though the dielectric may be punctured many times. When a short circuit occurs, the aluminum coating on the paper is melted by the spark, and all molten metal is blown away radially by the arc. This leaves a clean, insulated surface around the puncture. This in no way affects life.

METALITE METALLIZED PAPER CAPACITORS feature small size, lightweight, and a unique "self-healing" effect.

Of the three types available, type ML is cardboard encased, type MR metal encased, and type MQ encased in a tinned, non-ferrous shell. The latter type, MQ, is further divided into MQC, mineral wax impregnated, and MQM, mineral oil impregnated.

Astron Corp., 900 Passaic Ave., East Newark, N. J.

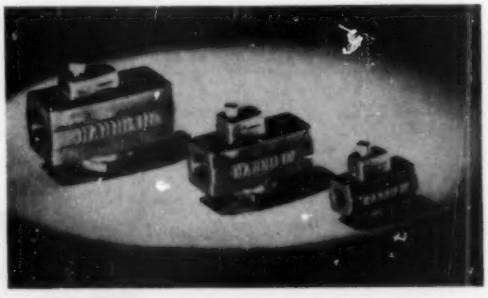
Type	Capacitance Range	Working Voltage d-c	Testing Voltage d-c	Maximum Operating Temperature	Insulation Resistance At 25° C
ML	.01 to 1.0 mf.	200	300	−60°C to +65°C	500 MΩ xmf. or 1500 MΩ
	1.1 to 2.5 mf.	200	300	−60°C to +65°C	500 MΩ xmf. or 1500 MΩ
	2.6 to 6.0 mf.	150	225	−60°C to +65°C	250 MΩ xmf.
	.01 to 2.5 mf.	400	600	−60°C to +65°C	1000 MΩ xmf. or 3000 MΩ
	.01 to 2.0 mf.	600	900	−60°C to +65°C	1000 MΩ xmf. or 3000 MΩ
MR	.05 to 1.0 mf.	200	300	−60°C to +85°C	500 MΩ xmf. or 1500 MΩ
	1.1 to 2.5 mf.	200	300	−60°C to +85°C	250 MΩ xmf.
	2.6 to 8.0 mf.	150	225	−60°C to +85°C	250 MΩ xmf.
	.05 to 4.0 mf.	400	600	−60°C to +85°C	1000 MΩ xmf. or 3000 MΩ
	.02 to 4.0 mf.	600	900	−60°C to +85°C	1000 MΩ xmf. or 3000 MΩ
MQC	.01 to 1.0 mf.	200	300	−60°C to +85°C	500 MΩ xmf. or 1500 MΩ
	1.1 to 8.0 mf.	200	300	−60°C to +85°C	250 MΩ xmf.
MQM	.01 to 4.0 mf.	400	600	−60°C to +85°C	1000 MΩ xmf. or 3000 MΩ
MD or MX	To Specification	Up to 600	Up to 900	−60°C to +85°C	

Speed Control Valve Has Unique Safety Feature

This speed control valve for use on pneumatic cylinders has an "O" ring seal above the threads on the valve stem. When the threads on the stem are almost disengaged, the seal lists and fails to seal, thus allowing air to escape with a loud hissing sound and warn the operator that the point of maximum adjustment has been reached.

This "Type S" valve is made in ¼, ⅜, ½, and ¾ in. pipe sizes. Construction is entirely of corrosion resistant materials. Pressures up to 150 psi are allowable. For speed control in both directions on double-acting air cylinders, two vaives are used—one in each of the lines leading to the cylinder ports.

Hannifin Corp., 1126 South Kilbourn Ave., Chicago 24, Ill.



CONTINUED ON PAGE 168

Announcing TWO BLIND RIVETS

FOR FASTER ASSEMBLY at LOWER COST

DIAMETERS: 1/8", 5/32", 3/16" and 1/4".
STANDARD HEAD TYPES: Brazier and 100° countersunk. Other head types on request.
MATERIALS: Aluminum alloys and cadmium-plated mild steel.
Huck PT
(Pull-Through Type)
Huck 9SP
(Self-Plugging Type)

THESE NEW FEATURES Will Save You Time and Money:

1 **LOW COST:** These Huck Blind Rivets are *lower in price* than any similar blind rivets. They're also faster and easier to drive, giving extra savings in time and labor.

2 **EXTRA-WIDE GRIP RANGE:** Huck PT Blind Rivets have *no minimum grip limitations.* Huck 9SP Blind Rivets have *more than twice the grip range* of all other self-plugging blind rivets. This simplifies both driving and inventory.

3 **POSITIVE SHANK EXPANSION:** Provides ample hole-filling to meet all normal requirements.

4 **NON-SPLITTING HEAD:** Special engineering features prevent splitting of the sleeve during blind head formation.

5 **EASE OF INSTALLATION:** Huck PT and 9SP Blind Rivets are unusually easy to install, for these reasons:

(a) Use of pull grooves on the pin tail greatly simplifies driving. Rivet is inserted in gun or hole with equal ease. Once inserted in the gun, the rivet cannot wobble, fall out, or move to cause improper engagement in the gun. This is particularly helpful in hard-to-reach and overhead applications.

(b) Pulling section will not break off prematurely, insuring a properly-driven rivet. The pin tail can't become jammed in the gun after the rivet is driven.

(c) Rivets are driven by single operator, from one side only, with manual or pneumatic pull gun. Adaptors permit using other types of pneumatic pull guns.

(d) Pull gun requires no adjustment for different grip lengths.

WRITE FOR ENGINEERING DATA

THE HUCK SCREW

Available in steel and aluminum; combines the advantages of bolts and rivets in one superior fastener. Pulls the work tightly together—fills the hole where required—fastens *permanently*—and has high strength. Rapidly driven by single operator. Full details on request.

Huck MANUFACTURING CO.

Specialists in Fastening and Riveting Processes

2480 Hellwig Avenue — Detroit 35, Michigan

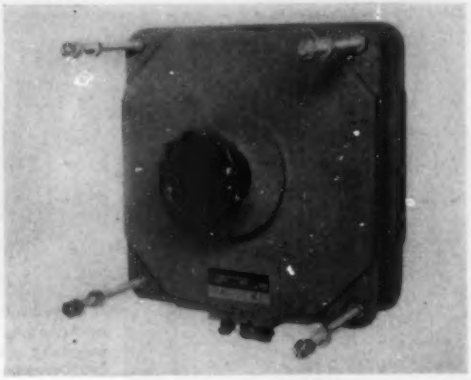
General Electric Announces New Plate-Type Rheostat

Made specifically for field control of dc shunt- or compound-wound motors, self-excited generators, exciters, separately excited generators and synchronous motors, this rheostat will be suitable for many machine installations, including motor-generator sets. There are three types available: the 6, 9, and 12 in. forms, with 27, 52, and 70 resistance divisions, respectively.

This rheostat features adjustable stops which limit the dial switch movement at each end of travel. These stops are adjustable through a 90 deg. angle and allow the adjustment of the maximum and minimum resistance possible to cut in or out of circuit. Handwheel operating mechanisms and sequence drives allow two plates to be operated in sequence by the rotation of a single handwheel.

Easily detachable conduit boxes, which cover the terminals, are provided as optional items for open type plates and standard items on enclosed plates.

General Electric Co., Control Div., Schenectady 5, N. Y.

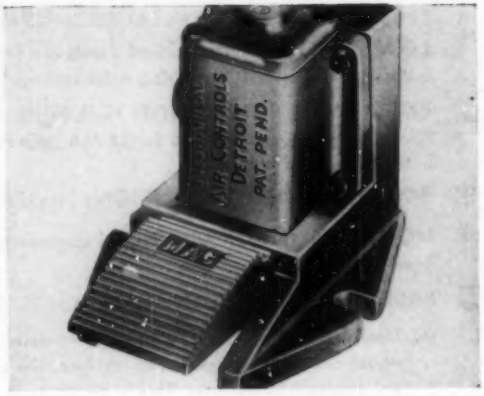


Foot Valves Have Locking and Unlocking Characteristics

This new line of foot valves, used for the control of both single and double acting cylinders, gives the operator the option of use as either a locking or unlocking type. The locking application is obtained by a slight forward pressure of the toe when pedal is in a depressed position. A slight downward pressure of the toe will release the locking mechanism and permit the treadle to return to the normal "up" position.

The body design embodies the one moving part—a hard chrome spool on which is mounted "MAC" "O" ring type seals. These seals enter the precision hard chromed lapped bores of the body and end caps, to effect instantaneous positive "sealed with air pressure" seal. All tapping ports are on the rear, to give greatest convenience for piping. The straight through flow of this valve, along with fast positive reversal of the treadle allows fast operation of the air cylinder.

Mechanical Air Controls, Inc., 3049 E. Grand Blvd., Detroit 2, Mich.



Drawing Board is Lightweight

Built of plywood, with the same honeycomb construction used in air frames, these boards combine lightweight with strength and rigidity. All elements are bonded with water-proofing glue, and the whole board has been dipped into a waterproofing agent. Boards are made in sizes from 12 to 31 in. in width and from 17 to 42 in. in length. They have many optional features, including: a Straight-Edge Gear-Rack Aligner (which takes the place of a T-Square); transparent plastic straight edges; and an envelope-type carrying case.

Cal-Pan Corp., 1111 S. Fremont Ave., Alhambra, Calif.

Paper is Non-Adhesive

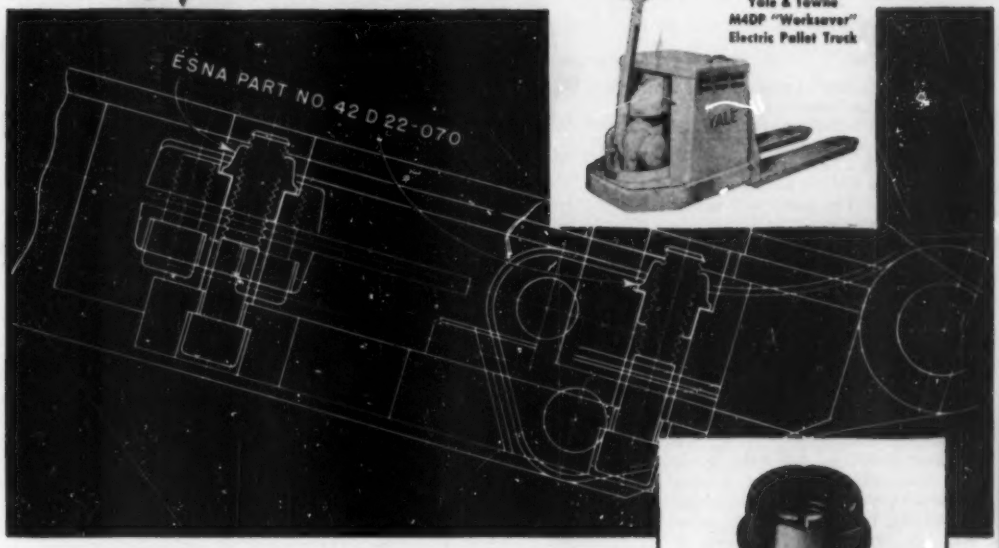
This Kraft paper will not adhere to rubber, asphalt, pressure sensitive tape, and most other adhesive materials. In appearance, color, feel, tensile strength, tear resistance, and other qualities, this paper is the same as an untreated paper. It is also water repellent, and comes in either high or medium finishes. Industrial applications include use with camelback, tire tube repair patches, pressure sensitive rubber tape, adhesive and friction tapes, and other adhesive materials. One of the many uses will be in the manufacture of containers for adhesives.

The Central Paper Co., Inc., Muskegon, Mich.

CONTINUED ON PAGE 170

Self Locking Spline Nuts

FOR COST-CUTTING PRE-ASSEMBLY METHODS



Yale & Towne M4DP "Worksaver" Electric Pallet Truck

—The Red Elastic Collar protects inaccessible bolted fastenings from failures due to VIBRATION!

After testing many types of fastenings Yale & Towne selected ESNA spline nuts as the solution for the blind mountings on the front and rear assemblies of the M4DP "Worksaver" Electric Pallet Truck featured in this ad. Loose bolts at these inaccessible locations meant loss of adjustment and mechanical wear. Their research proved that self-locking connections at these application points provided protection against unnecessary down time . . . added assurance against service calls and repairs.

This is a typical example of the growing industrial acceptance gained by ESNA spline nuts . . . especially designed for easy driving into soft gray iron, magnesium or aluminum castings. By means of this simple installation the casting is given a threaded member; a tough drilling operation is speeded up because the drill is allowed to run through the casting . . . costly tapping operations are eliminated. The self-locking collar does away with expensive cap screw lock wiring and fully protects inaccessible or blind mountings from operating failures.

In addition, if dis-assembly is required, ESNA spline nuts remain securely positioned for quick reinstallation and the famous Red Elastic Collar provides adequate locking torque for repeated re-use.

This is only one of many types of standard Elastic Stop Nuts available for special industrial fastening problems.

HERE'S A CHALLENGE: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Write: Elastic Stop Nut Corporation of America, Union, N. J. Representatives and Agents are located in many principal cities.

THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. **Protects against nuts loosening due to VIBRATION**
2. **Keeps locking threads CORROSION FREE**
3. **Provides for accurate BOLT LOADING**
4. **Seals against LIQUID LEAKAGE along the bolt threads**

ELASTIC STOP NUTS

HIGH TENSILE

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

NYLON CAP

OVER 400 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

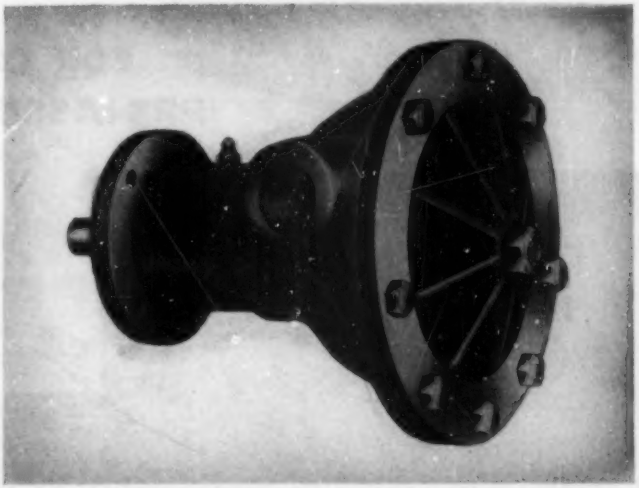
Floating Vane Pump Has New Type Action

The new "Cleco" pump features a pumping action resembling that of a square piston traveling smoothly and continuously in a square cylinder of infinite length. This action gives the features of a turbine having positive displacement. The pump will handle liquids, gases or air.

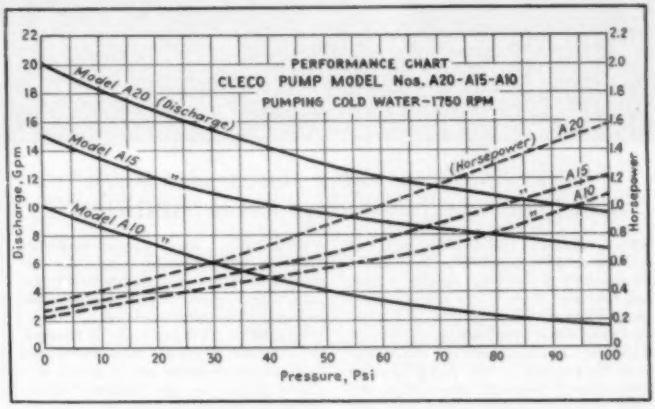
A unique arrangement of the yoke-cross head and off center pin give good radial control of the vanes, and the use of Preloaded Deep Groove Sealed Ball bearings give firm lateral control. This accurate control allows the vanes to "float" in the working chamber without touching either the sides or race. Wear is therefore at a minimum, even when pumping non-lubricating fluids.

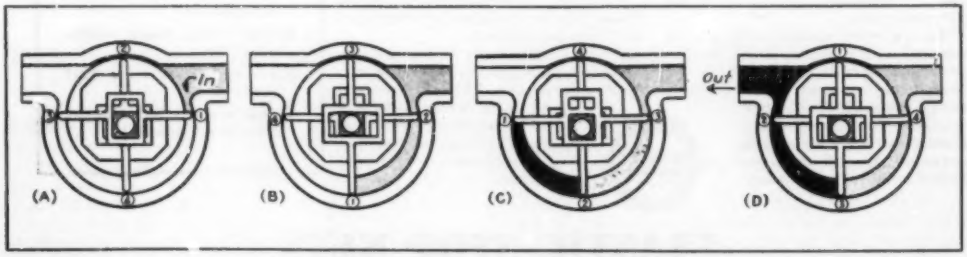
These pumps are self priming, do not contaminate liquids by bearing lubrication, and will handle liquids up to 212 deg. F. They operate in either direction, and will pump light or heavy fluids at high vacuum and static head. They are made of cast iron, bronze, or cast iron with bronze fittings, and pump 10, 15, or 20 gpm at 0 psi, depending on size. Recommended operating pressures vary from 0-50 to 0-70 psi, depending again on size. These pumps have 1 in. suction and discharge pipes.

Chicago Laboratory & Engineering Co., 4140 N. Kedzie Ave., Chicago 18, Ill.



FEATURES INCLUDE: floating vanes, rotary positive displacement, greater volume and pressures in non-lubricating fluids without wear, new mechanical seals, new pumping action, and an oversized shaft.


PERFORMANCE CHART
CLECO PUMP MODEL Nos. A20-A15-A10
PUMPING COLD WATER—1750 RPM
Model A20 (Discharge)
Model A15 "
Model A10 "
(Horsepower)
A20
A15
A10
Discharge, Gpm
Horsepower
Pressure, Psi
0 2 4 6 8 10 12 14 16 18 20 22
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
0 10 20 30 40 50 60 70 80 90 100



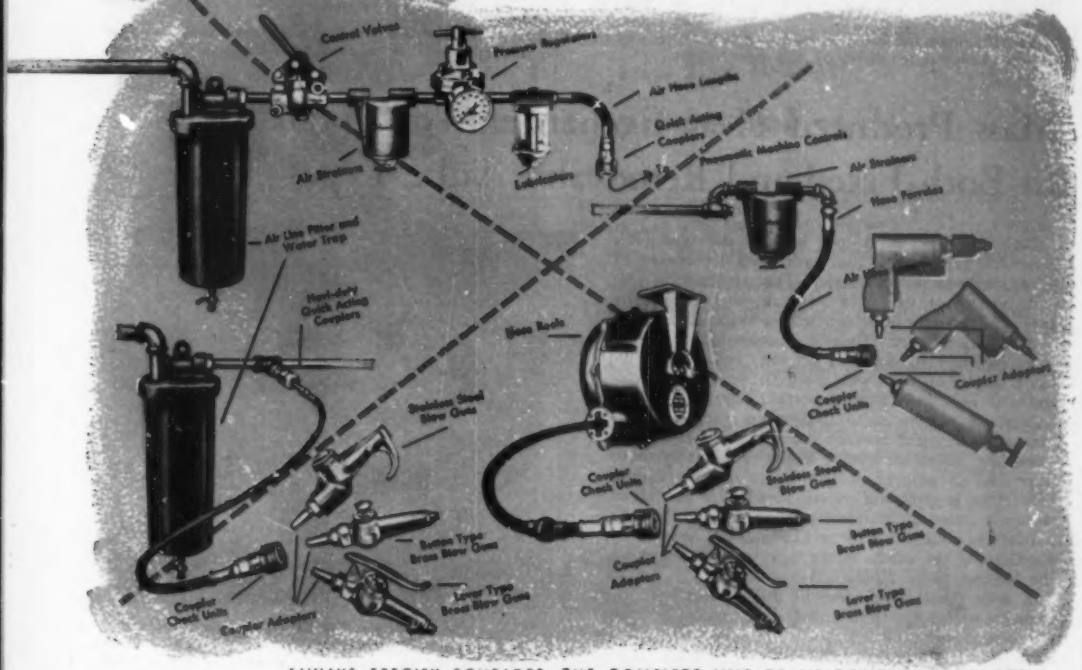
UNIQUE off center pin and yoke-crosshead give positive displacement. In (A), above, vane 1 creates a vacuum behind it as it is pushed out of the rotor and into the pumping chamber. In (B), vane 1 has been pushed out its maximum stroke and has filled the chamber between it and vane 2. In (C), vane 1 is being withdrawn into the rotor to allow fluid to discharge. Vane 2 acts as a square piston. In (D), vane 1 is completely withdrawn, and vane 2 has started its withdrawal.

CONTINUED ON PAGE 172

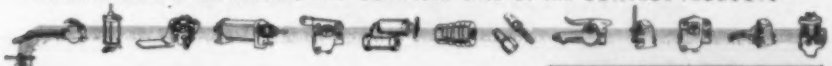
Everything for the air line from the wall to the end of the air hose.....

Start with, improve with, replace with genuine Schrader Air Control Products

Regardless of the kind of air system you now have or whether you are planning to expand the use of compressed air in your operations . . . you owe it to yourself to see Schrader now! It's the most modern line—with many new types of controls, the complete line—with practically everything you can think of, every product planned to increase production, save air, reduce maintenance, and eliminate air losses. And it's backed by Schrader factory representatives and the nation's finest distributors—ready to help you. Send in the coupon . . . today!



ALWAYS SPECIFY SCHRADER, THE COMPLETE LINE OF AIR CONTROL PRODUCTS



Schrader
PRODUCTS CONTROL THE AIR

4. MAIL THIS COUPON TODAY

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Division of Scovill Manufacturing Company, Incorporated

Please send me information and free literature about the products I have checked in the squares at the right.

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COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

PE

	Check Here
Air Cylinders	
Operating Valves	
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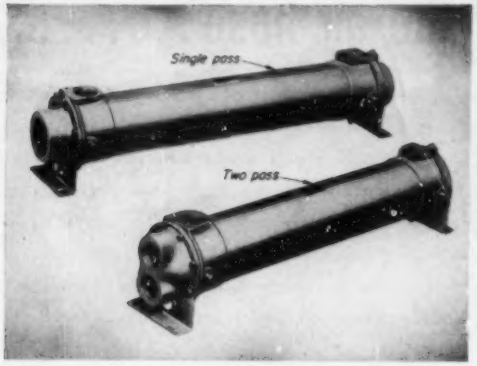
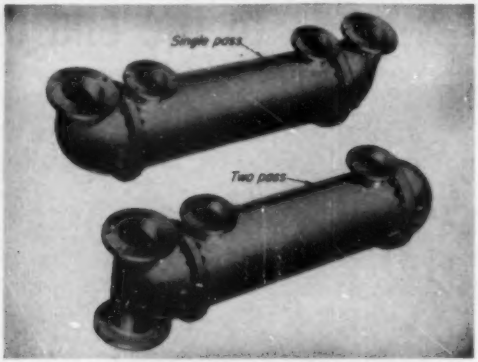
Air Line Couplers	
Air Hose & Fittings	
Hose Reels	
Hydraulic Gauges	
Pressure Regulators & Oilers	
Air Strainers	
Uniform Tube Fittings	



TYPE "F", single and two pass fixed tube heat exchangers are for small temperature differentials and short lengths.



TYPE "R" SINGLE and two pass heat exchangers have removable tube bundles. They handle higher temperature differentials.

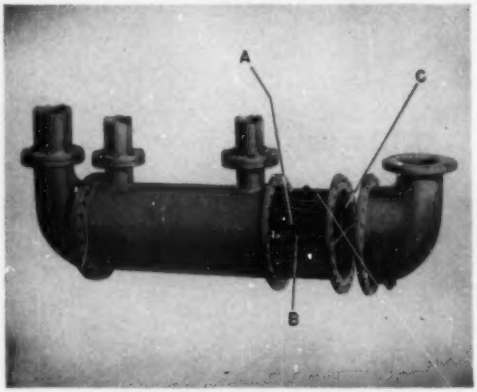
Mass Produced Heat Exchangers Are Available In Both Fixed and Removable Tube Types

Both type "F" fixed tube bundle, and type "R", removable tube bundle heat exchangers are offered in either single or two pass styles. They are made in such wide variety of sizes and materials, that almost any application need may be met with a stock model.

The design is basic. Type "F" consists of a bundle of tubes having a fixed header on each end. Type "R" has a bundle of tubes with a fixed header on one end and a floating header on the other. The type "F" is particularly well suited to applications where the temperature differential between the two fluids is not too great, and where the overall length is relatively short. Type "R" is adapted to uses where the temperature differential is great and overall lengths are enough to require a means of relative expansion between the tube bundle and shell. Also, the end castings can be removed for cleaning the inside of the tube without disturbing the position of the piping.

A wide selection of materials makes these heat exchangers useful for fresh or salt water cooling. They can be used with pressures up to 75 psi and temperatures up to 300 degrees Fahrenheit.

Young Radiator Co., Racine, Wis.



TYPE "R" has a removable tube bundle, (A) for easy maintenance. Baffles, (B) provide turbulence in fluid for maximum heat transfer. Tubes (C) are rolled into header and expanded to form a sturdy joint. All parts are standardized for lower cost.

Sample Kit Helps to Solve Sealed Terminal Problems

The New E-I Sealed Lead and Multiple Header Kit contains a wide assortment of standard hermetically sealed terminals in one case in compartments labeled for easy selection. The many standard types included are capable of solving most applications requiring hermetically sealed terminals. The E-I Sample Kit contains 81 standard terminals and 11 stock header types.

The assortment is contained in a transparent case of convenient size. Clearly labeled partitions help keep the kit orderly and make lead identification simple.

A new brochure containing individual folders on sealed leads, multiple headers and gasket type bushings for heavier equipment gives full engineering information on stock items found in the kit. This brochure comes as part of the kit.

Electrical Industries, Inc., 44 Summer Ave., Newark 4, N. J.

CONTINUED ON PAGE 174

use CASTINGS by PERMITE

. . . for lower production costs

Users of aluminum castings have learned it pays to use "Castings by Permite." Their greater tensile strength, close tolerances, consistent uniformity help metalworking manufacturers speed production and save on parts and labor costs. Aluminum castings that will best serve your specific needs are assured by Permite's unexcelled facilities for producing permanent mold, sand and die castings. Submit your parts requirements to Permite for prompt recommendations and quotations.

ASK FOR NEW 80-PAGE CASTING MANUAL

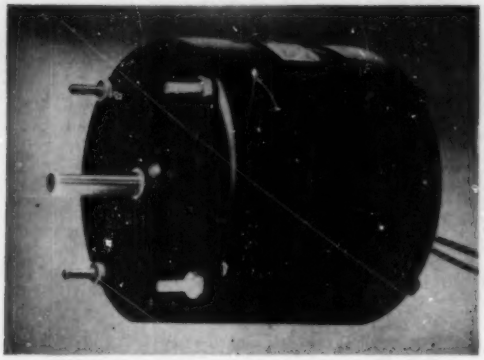
Authoritative illustrated manual on the design, production and uses of aluminum castings. Includes casting alloys tables. Sent free on request to interested executives.

PERMITE

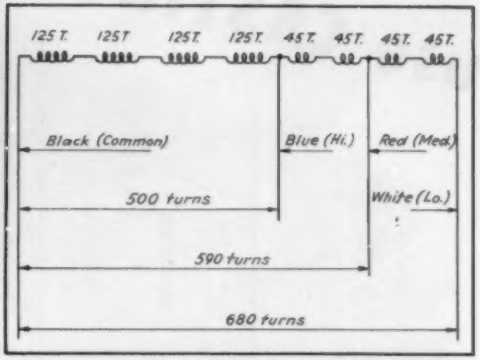
ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS... HARDENED, GROUND and FORGED STEEL PARTS



TRI-MOTORS are available in either the 4 or 6 pole types, in 2 or 3 speed models, and from 1/40 to 1/8 hp sizes.



TYPICAL 4 pole, 3 speed Tri-Motor has coils wound 170 tpc, with tap at 125 turns. Each use requires different windings.

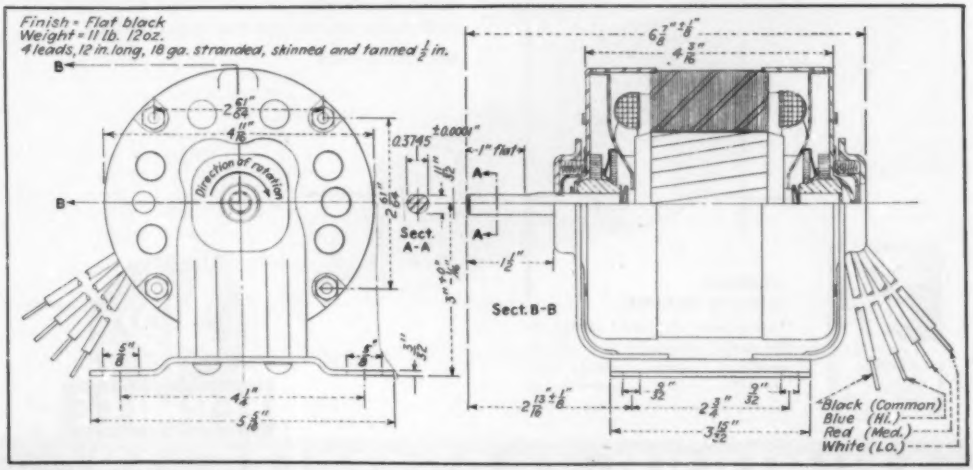
Three-Speed Motor Has Built-in Speed Control

This Shaded pole motor has no external choke coil or resistor.

By making the lamination iron do double duty, first in its normal function as a motor, and then as a core for a choke coil, this shaded pole motor does away with all external speed controls.

Especially useful for fan or blower operations, the Tri-Motor is first wound with the total number of turns required for the lowest operating speed. For the medium and high speeds, the coil is tapped at the number of turns required, and a connection brought outside from the point of tapping. When the floating load of a fan or blower is put on the motor, it will run at its high, low or medium speed, depending on the circuit connections. With no load, all three connections will give exactly the same speed.

In choosing applications for the Marco Tri-Motor it should be remembered that the speed reduction will only work on a floating load such as that supplied by a fan blade or blower wheel, and cannot be used on power applications, where reduced power on the low and medium connections would merely stall the motor. Actually, a voltage reduction merely reduces the horsepower to the point where the load will pull the speed down to normal operating conditions. With no load, all three connections give the same speed. The difference is all in the horsepower output.



OUTLINE DRAWING and section show general construction of Tri-Motor. Motors have drawn steel or aluminum die-cast end bells, choice of resilient or rigid base, and either aluminum die-cast or Heliarc welded copper rotor construction.

Marco Industries, Inc., 1614 Terrace Blvd., Depew, N. Y

CONTINUED ON PAGE 176

Only the BEST pass these tests

The spectrograph provides one of the most efficient means for precise metallurgical control. Samples taken from a heat in the Driver-Harris melting furnaces are analyzed so rapidly by means of this apparatus, that a complete analysis can be obtained before the next heat is ready for pouring. Thus any necessary adjustments can be made immediately—an outstanding advantage in controlling the constituent elements of alloys being produced to extremely close specifications. The operator is here seen adjusting the size of the analytical gap in the arc-spark stand of the Driver-Harris grating spectrograph at the start of an exposure.

The quality of any manufactured item depends upon a number of factors, but on none so much as "inspection". And here, at Driver-Harris, we give top priority to inspection.

Through every stage of manufacture, precise metallurgical checks and controls are systematically applied to D-H Alloys to insure quality and uniformity that are unsurpassed—recognized the world over.

We have had 50 years' experience in continuous alloy research and manufacture. Every piece of D-H wire, ribbon or strip, and every casting embodies advantages such as only half a century of accumulated know-how can provide.

Whatever your requirements for electrical resistance and heat-resisting alloys, send us your specifications. We shall be glad to make recommendations, and supply you with the alloy best suited to your needs.

This operator is viewing the projection of a series of spectrograms, and is about to measure the intensity of specific spectral lines to determine the quantity of certain chemical elements in the samples being analyzed.

The research metallograph, the ultimate in metallurgical microscopes, is applied to both research and quality control at Driver-Harris.

A view in the Driver-Harris chemical laboratory —fully equipped for all standard types of volumetric, gravimetric and colorimetric analyses.

FIFTIETH ANNIVERSARY

SPECIAL PURPOSE ALLOYS SINCE 1909

D/H

TRADE MARK REG. U. S. PAT. OFF.

*Makers of over 80 alloys for the electronic, electrical and heat-treating fields—including world-famous Nichrome**

Driver-Harris Company

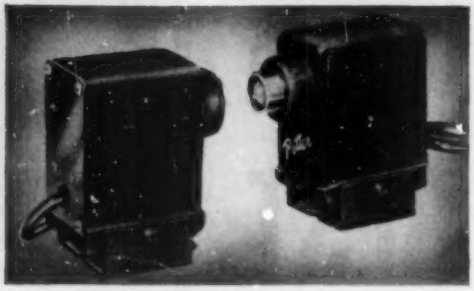
HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. Reg. U. S. Pat. Off.

Two High Speed Photo-Electric Count Detectors Are Announced

MODEL 607 has two identical housings; one for the light source and the other for the photo-cell and amplifier. By interchanging the lenses, two types of photoelectric beams are obtained. The first is a parallel beam of ½ in. dia. which can be used at distances up to 6 feet between units. The other is a focused spot, ⅛ in. in dia., obtained when the two units are 6 in. apart.



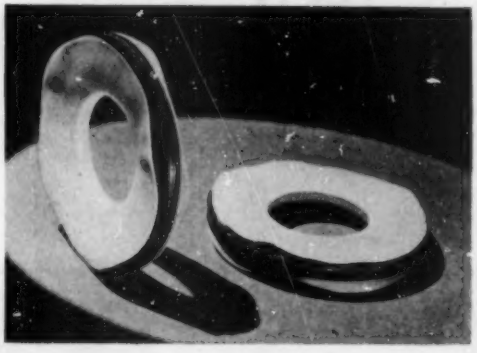
MODEL 608 is an integral unit containing both the light source detector and amplifier. A fine focused spot $\frac{1}{16}$ in. in dia. is obtained midway between the light source and detector. Since this detector will respond to light changes as small as 20 percent, it is useful for the high speed counting of small objects, as well as parts that are closely spaced. Both units have cast aluminum housings.

Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.

Non-corroding Adaptors Seal Glass Coated Pipe

Giving a chemically inert yet mechanically perfect seal between glass-coated steel pipe and other materials, these adaptors are non-corroding and non-contaminating. A Teflon jacket effects the seal. It is the only part of the adaptor exposed to material within the pipe, and is so chemically inert that it can neither affect nor be affected by any known industrial chemical. It withstands temperatures up to 550 deg F, and down to —150 deg F. Various resilient materials are used inside the Teflon jacket.

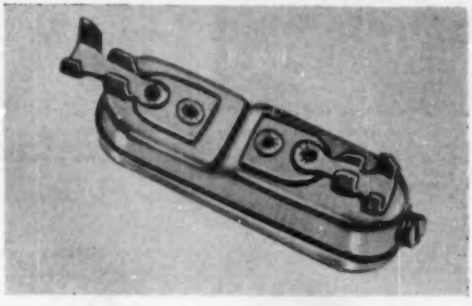
United States Gasket Co., 602 North 10th St., Camden, N. J.



Miniature Thermostat Has Pilot Control Applications

Weighing only 1/10 of an ounce and measuring 1 in. in length, this small thermostat has an electrical capacity of 100 watts, ac, at 115 volts. The small thermostat is totally enclosed and mechanically strong. It has wire-clinch terminals and can be furnished with normally open or normally closed electrolitic silver contacts. Temperature adjustments from 0 to 400 deg F can be made with a single adjusting screw.

George Ulanet Co., 410 Market St., Newark 5, N. J.



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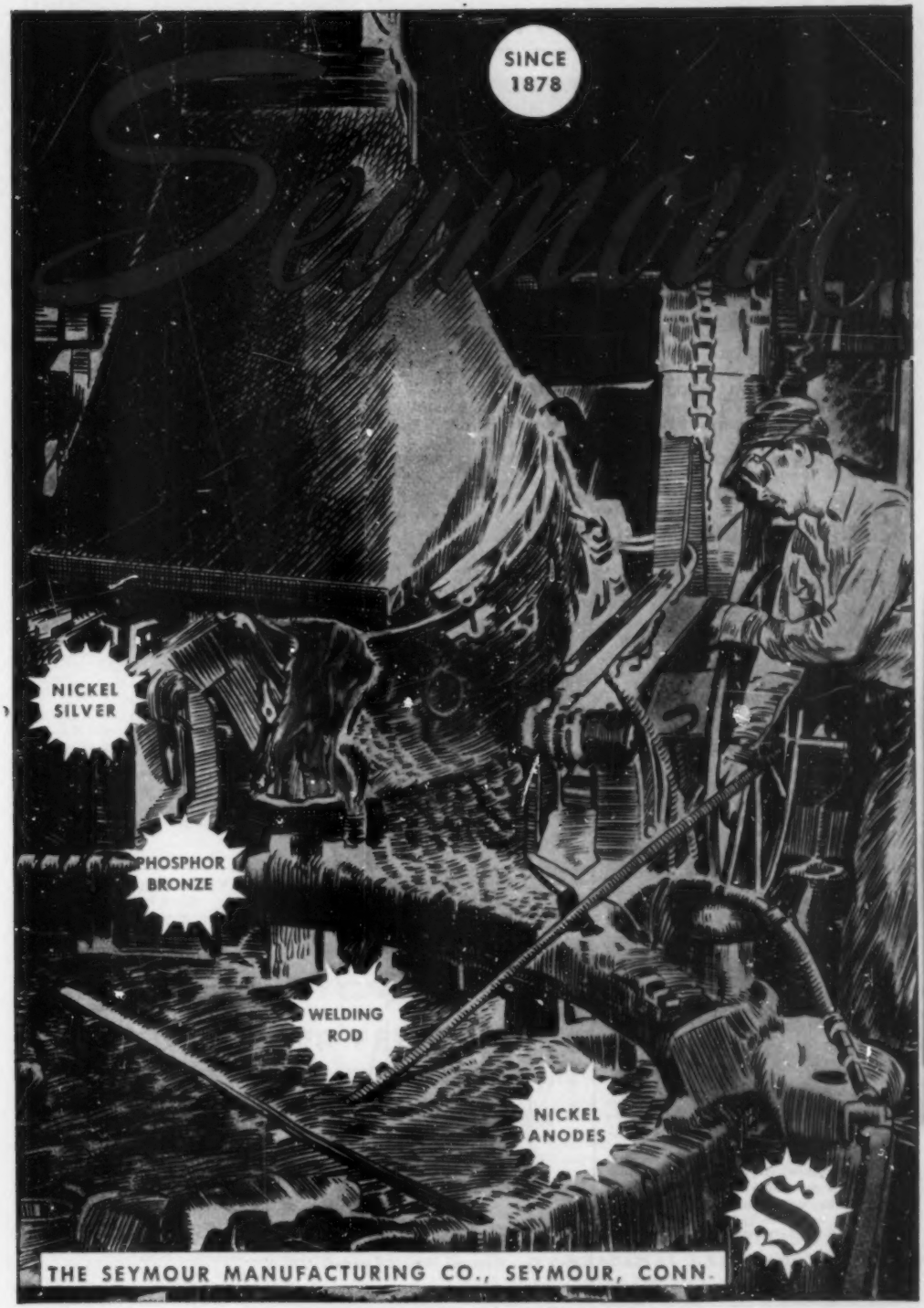
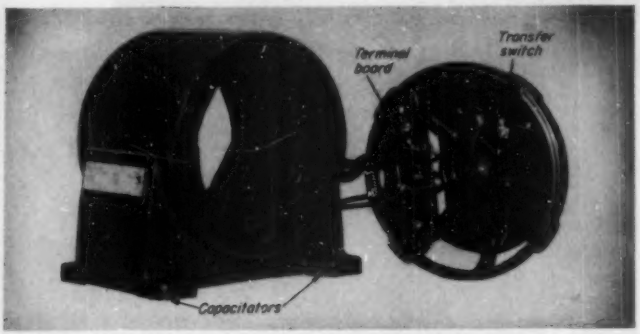

SINCE
1878
Seymour
NICKEL
SILVER
PHOSPHOR
BRONZE
WELDING
ROD
NICKEL
ANODES
S
THE SEYMOUR MANUFACTURING CO., SEYMOUR, CONN.

BUILT-IN TERMINAL BOARD (with cover removed, above) shortens and simplifies wiring the motor, and requires less mounting space. Reversing the capacitor lead will reverse motor.

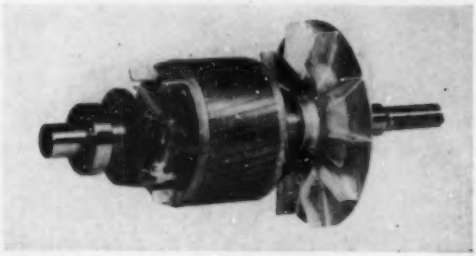


STATOR CORE is built-up of laminations of non-aging, high silicon steel, factory annealed. It is preassembled and seam-welded. Windings are made of Formex wire and varnished to form a rigid unit. Capacitors are mounted in the KCS motor base. They can be removed by tipping up the motor and removing two screws. They are moisture-proofed and protected from damage by the heavy motor base.

Single-Phase Motor Is Compact, Sturdy

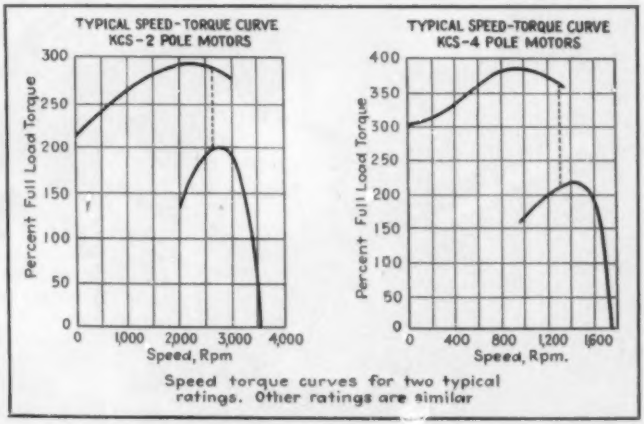
Made in either capacitor-start (KCS) or capacitor-start-and-run (KCR) models, these new motors have four principal advantages. They offer a 15 to 20 percent weight reduction; a new, totally enclosed transfer mechanism; long life ball bearings; and a new terminal board that cuts wiring time.

The KCS model operates on 115/230 v, 60 cycles; and the KCR model on 230 v, 60 cycles. The KCS comes in ½ through 5 hp sizes, and the KCR in 1 through 5 hp ratings. All pertinent dimensions and ratings are in accordance with established NEMA standards.



ROTOR WINDINGS are of cast aluminum. Slots are skewed, and the slot-and-tooth combination is designed for quiet operation. The cast-aluminum fan gives through ventilation. Rotor is dynamically balanced by the use of small weights placed into the end ring grooves and crimped securely into place.

TRANSFER SWITCH at left, and centrifugal mechanism at right, automatically reconnects the stator windings from the starting to the running condition. The switch is totally enclosed by a Textolite cover to exclude foreign matter.



Speed torque curves for two typical ratings. Other ratings are similar

General Electric Co., Apparatus Dept., Schenectady 1, N. Y.

CONTINUED ON PAGE 180

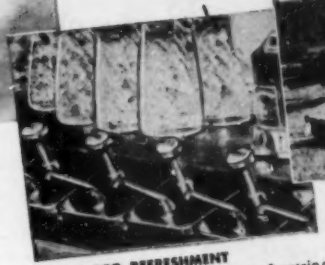
Small Castings that do BIG JOBS

Forward-looking design engineers find that Microcast, for small components, offers many opportunities for product improvement and substantial savings in cost. This is particularly true where resistance to wear or corrosion is desired or where the part is of intricate shape, requiring expensive machining operations under conventional production methods.

With the Microcast Process, the unusual properties of the extremely hard, high-melting-point alloys can be used to full advantage. Small components of intricate shape, as cast, are dimensionally uniform, of sound structure, and to such close tolerances that little or no machining is required.

SPECIALISTS IN POWER BLADING

The "guts" of any turbine-type power development unit is its power blading. The Microcast Process has produced millions of these blades, utilizing the high-melting-point, non-machineable alloys at substantially lower costs than other methods of manufacture.



TIME FOR REFRESHMENT

When you step up to your favorite fountain chances are the syrup for your soda, pumps through a Microcast dispensing part. What's important is that these 18-8 stainless steel Microcastings resulted in considerable savings in die and machining costs over previous production methods.

IT AIN'T HAY

At least the operation is not complete until the modern hay baler goes into action! A Microcast gear on the knotter twine disc assembly eliminates the costly milling and hobbing operations ordinarily required to form teeth.

Microcastings...IN A WIDE VARIETY OF PRODUCTS

AFFORD BETTER PERFORMANCE AT LOWER COST

Write for New Microcasting Booklet

MICROCAST PRECISION CASTINGS PROCESS

MICROCAST

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More complete information on Microcast is contained in a new 16-page booklet published by Austenal Laboratories, Inc., originators of the Microcast Process. The booklet describes many applications for Microcasting and also explains the process itself. Write for your copy today.

The name MICROCAST is a registered trademark of Austenal Laboratories, Inc.

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

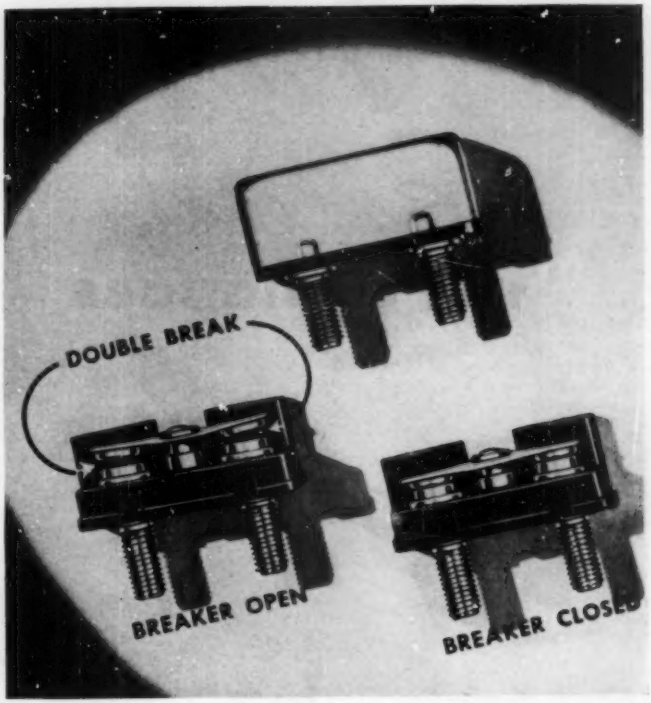
Automotive Type Circuit Breaker Is For Low Voltage DC Circuits

Called the Klixon C9121, this breaker is designed for use in low voltage dc circuits on transportation equipment, battery chargers, and other low dc circuits. Available in ratings of 8, 10, 15, 20, 25 and 30 amps., these breakers are small and compact, and of simple design.

Utilizing a double break contact action, the standard unit can be used on all 6 and 12 volt dc applications and on many of 24 volts. The unit's inherent thermal time lag characteristics avoid nuisance tripouts by harmless transient shorts, and at the same time permit safe limit operation.

All types are calibrated to carry at least 100 percent of nominal rating continuously and to trip ultimately at not more than 125 percent of nominal rating when in an ambient of 77 deg. F. Being a thermally actuated breaker, the performance characteristics vary with the ambient temperatures.

Metals and Controls Corp., Spencer Thermostat Div., Attleboro, Mass.



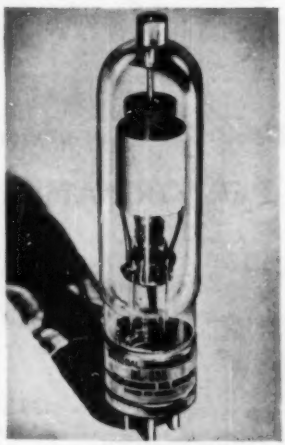
Quick Heating Rectifier Tube Replaces Gas-Filled For Industrial Control Applications

Model NL-635 mercury vapor 6.4 ampere rectifier tube is available with either an industrial or bracket type base, and is designed for interchangeability with inert gas-filled rectifiers. The mercury vapor filling permits use of the tube at higher voltages and gives maximum life without circuit "cushioning." The model NL-635 is designed for industrial power rectifier applications up to 250v, dc. The No. 412 industrial base has four pins. The bracket type base is for panel mounting.

SPECIFICATIONS:

Maximum output, dc	6.4
Maximum output, instantaneous	40.
Maximum peak inverse volts	1000
Filament volts	2.5
Filament amps	18 ± 2

National Electronics, Inc. Geneva, Ill.



Plastic Oil Cup Keeps Oil Supply Visible

Made of clear, shatterproof plastic and reinforced with ribs for extra strength, this oil cup also serves the purpose of an oil gage. The combination oil cup and oil gage is available in 1, 2, 4, and 8 oz. sizes. It has a large, self-closing, dustproof filler cap for easy filling and cleaning. The steel base is cemented and roll-clenched to the plastic reservoir to eliminat· possible leakage. These oil cups should not be installed in locations where the temperature is above 170 deg F. However, the visible oil level feature makes it possible to install the oil cup well away from the machine, or away from heated areas, and still be able to keep an accurate check on the oil supply. All parts steel are heavily plated to resist corrosion.

Trico Fuse Mfg. Co., 2948 N. 5th St., Milwaukee, Wis.

CONTINUED ON PAGE 182

BACK IN THE 80's

Jacketed mixing tank.
Stainless steel inside.
Steel outside.

WHEN THE FIRST POWER OPERATED SEMAPHORE WAS INVENTED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

In every phase of industrial and business activity, there is a constant drive for improvement of methods and devices that can save money, time or human energy. That explains why, for seventy years, equipment manufacturers have relied on KOVEN for individualized equipment parts. Our vast facilities and quality craftsmanship, combined with time-perfected techniques, enable us to supply a part or parts of any finished product to exact specifications, in less time and often at a lower cost than they could be made in your own plant. Call or write now—one of our representatives will advise you without obligation.

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Vacuum cooking kettle of stainless steel

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881

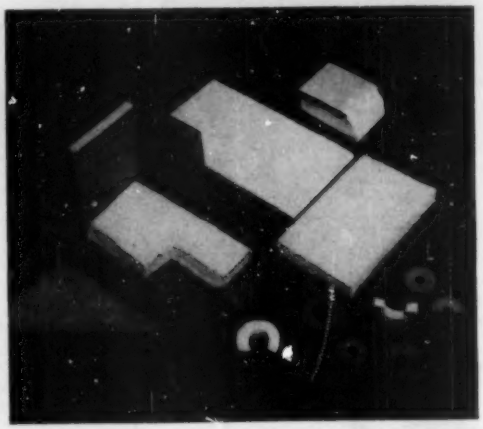
Silicone Rubber Products Have Uniform Cell Structure

Up until now, silicone rubber has been available only as a mechanical rubber or as a rubber form having uncontrolled cell structure. It can now be furnished in sheets, cord, strips, and tubes, die cut shapes, and molded forms. Cell structure may be chemically blown interconnecting cells or closed cells.

The new process yields a cellular rubber identical to natural cellular rubber in all considerations of uniform cell structure, compression, flexing, tensile strength, and softness, except that all these characteristics are retained at the high and low temperature extremes which cause natural cellular rubber to loose efficiency.

The company's best heat resistant compound of natural rubber deteriorates after one day at 300 deg F as compared to little change in their silicone cellular rubber after 35 days at 300 deg F. Even as much as 7 day's aging at 400 to 425 deg F reveals little change in softness of the silicone cellular rubber. At the other end of the temperature scale, silicone cellular rubber retains its efficiency down to —70 degrees. This contrasts with a compression change of 25 to 40 percent at —40 deg for the company's average natural cellular rubber.

Other attributes claimed for silicone cellular rubber are



a chemical stability far superior to that of natural cellular rubber and non-toxic properties of especial value in food processing. Also, this new rubber has less than half the weight of mechanical rubber.

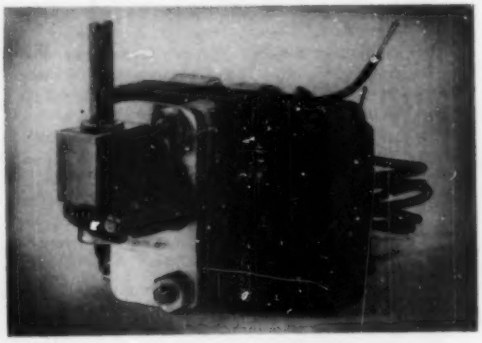
The Sponge Rubber Products Co., Shelton, Conn.

Worm Drive Motor Assembly Is Small, Inexpensive

Made to compete with spur gear motors, these worm drive assemblies will find their greatest usefulness in coin-operated machines, animated advertising displays, and similar light applications. They are made in speed ranges from 400 to 25 rpm. There is no standard assembly for this model. Dimensions and specifications depend upon the output speed required.

One advantage this assembly has over the spur gear type is in absence of gear noise. There is another advantage in having the drive shaft parallel to the motor frame. This is a distinct advantage in many applications.

Gleason-Avery, Inc., Auburn, N. Y.



Set Screw Is Self-Locking and Self-Adjusting

The new "Zip-Grip" set screw is specifically designed for set screw applications where excessive vibration is a factor, and for regulating and adjusting applications, where instantaneous locking at a precise point is desired. The lower part of the "Zip-Grip" set screw has standard threads. The upper part of the threaded section has a larger pitch diameter than normal. This upper threaded section creates an interference or expansion fit, which results in one part of the threaded section being drawn in one direction and the other part being drawn in the opposite direction. For this reason there are three types of locking action in effect: the tension fit noted above, an interference fit, and the normal locking action of the set screw against the shaft.

These set screws are made in all the usual metals, including several types of steel, brass, bronze, and aluminum. They are available with any standard type head. Since no outside locking devices are used, the "Zip-Grip" should present a saving in assembly time.

Set Screw & Mfg. Co., Bartlett, Ill.

CONTINUED ON PAGE 184

QUALITY

OIL-CUSHIONED BEARINGS

FINISHED MACHINE PARTS

★ 20 years of production experience.
★ New plant and equipment.
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★ 3000 additional engineers for consultation on technical problems.
★ Depots in every state and throughout Canada for on the spot service.

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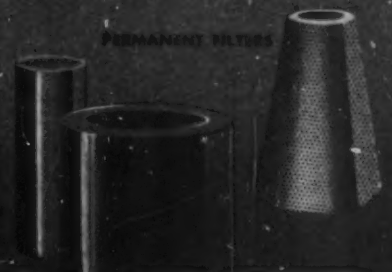
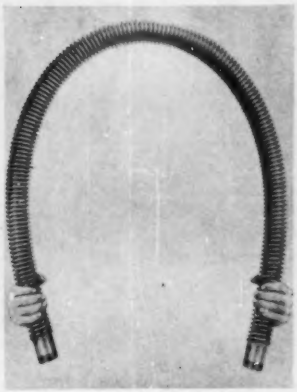


OILITE

AMPLEX MANUFACTURING CO.
DIVISION CHRYSLER CORPORATION
6501 HARPER, DETROIT 31, MICHIGAN



Flexible Hose Features Corrosion Resistance

Made of Carpenter Stainless No. 20 alloy, this new flexible hose is particularly suitable for use with sulfuric, formic or acetic acids and other comparable corrosives. The hose will find its greatest usefulness where vibration or motion in a machine makes a flexible hose necessary and corrosive fluids must be handled.

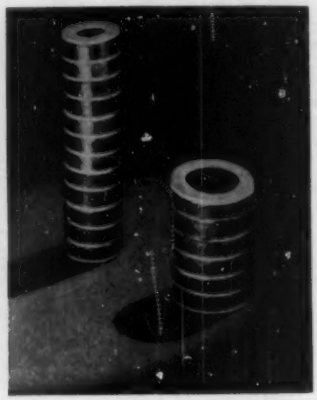
Size ranges vary from 1 to 2½ in., inside diameter, in a variety of gages to meet individual requirements. A number of standard pipe size nipples and other fittings are available. They can be welded, or the hose can be provided with non-flexible standard tube sizes for use with flanges.

Carpenter Steel Co., Alloy Tube Div., Union, N. J.

Phase Converter Extends Use of Three Phase Motors

In locations where only single phase current is available, a Withey Phase Converter allows the use of standard three phase equipment. There is not only the advantage of being able to use machines that come equipped with three phase motors, but also the usual saving in original cost and power consumption when using three phase motors. Also, three phase installation is simpler, and does not require the heavy wire used for single phase equipment. The only moving part is a small relay that is factory adjusted before shipping. Available size ranges are from ½ to 7½ hp capacities.

M. C. Wickham, 11073 Horton Rd., Goodrich, Mich.



Shaft and Pump Packing Is Non-Corroding

Made with alternating rings of solid, unoriented Teflon, and of graphite or mica combined with Teflon, this Chemiseal No. 711 packing is adapted for applications where protection from acids, solvents, or alkalies is required, or contamination of the product is a problem.

Under even slight gland pressure the graphite-filled rings are forced into a leak-proof seal against the shaft periphery. The natural lubricating properties of both the graphite and the Teflon make any additional lubricant unnecessary in many applications. Alternate layers of Teflon give a positive chemical seal.

United States Gasket Co., 602 North 10th St., Camden, N. J.

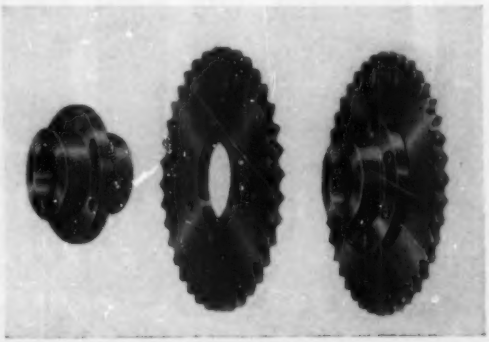
Roller Chain Sprockets Have a Demountable Hub

This line of "DH" sprockets consists of a steel plate sprocket, and a machined cast iron hub. The hub is the same as the one used in V-belt sheaves made by the same company.

One hub will fit a wide range of sprockets, thus making it possible to change to a larger or smaller plate size without removing the hub. Also, sprockets can be easily reversed when worn, thus presenting new tooth surfaces to the chain. All bolt holes are jig drilled to permit complete interchangeability.

Sprockets are available in pitch sizes ranging from ½ through 1¾ in. Hubs are carried in stock in bore sizes ranging from ½ to 4 7/16 in., with sizes increasing between these limits in increments of 1/16 in. They are provided with standard key ways and two set screws.

Fort Worth Steel and Machinery Co., 3600 McCart St., Fort Worth, Texas.



END

Princess Place Mats made from thin flexible sheets of Koppers Polystyrene 8. Designed and produced by The Ullman Co., Inc., 230 Fifth Ave., New York, N. Y. Extruder: The Plax Corporation, West Hartford, Conn.

Colorful place mats made from POLYSTYRENE SHEET

These beautiful Princess Place Mats sell on sight. They come in patterns taken from the finest lace and fabrics, reproduced on thin flexible sheets of Koppers transparent Polystyrene 8.

Sales for the first six months of '49 were 30% ahead of the preceding year. The reason for this is obvious. Women can make a beautiful table setting at a fraction of the cost of expensive fabrics. And they can use the mats over and over again. There's no washing and ironing. A damp cloth will clean the mats in a jiffy. The mats lie flat—do not curl up under hot dishes and give long satisfactory service.

Koppers Polystyrene 8 was selected for this use because of its superior heat resistance, transparency and low cost, and the free-flowing and quick-setting qualities of Koppers Polystyrene 8 facilitate production.

Another important quality is the ease of decorating Koppers Polystyrene. The finest patterns can be reproduced in minute detail. Colors do not rub off or smear.

What can you make from polystyrene sheet?

Extruded sheets of Koppers Polystyrene are available "paper-thin" or in thicknesses up to .090 inches . . . in water-clear transparent or in any desired color. Uses include place mats, packaging materials, advertising displays, novelties, book covers, etc. Our technical specialists will be glad to advise you on the techniques of using sheet polystyrene.

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NEW BOOKS

U.S.A.—Measure of a Nation

A Graphic Presentation of America's Needs and Resources

THOMAS R. CARSKADON *and* RUDOLF MODLEY. 161 *pages*, 8½ x 11 *in. Prepared by the Twentieth Century Fund. Published by The MacMillan Company, New York.* $1.

America's Needs and Resources

J. FREDERIC DEWHURST AND ASSOCIATES. 812 *pages*, 7¼ x 10¼ *in. Published by The Twentieth Century Fund, New York.* $5.

Engineers have often been accused of lack of interest in the effect of their efforts on the world about them. Engineers who deny this thesis are certain to find this book interesting. Within this 100-page volume, Mr. Carskadon, who is the chief of the Twentieth Century Fund Educational Department, and Dr. Modley have condensed the essence of a classic study by J. Frederick Dewhurst & Associates, "America's Needs and Resources", published by the Twentieth Century Fund in 1947. The condensation is designed to give the reader a highspot knowledge of the resources, including national riches, manpower and machines, which we have used to meet our needs. There also is a projected study on what our requirements are likely to be in each major field in 1960, and the resources we shall have to meet them if we do in the future as well as we have done in the past. It is hard to describe in words the sweep and range of this study on our entire American economy. Dr. Dewhurst's original book is an 812-page volume, extremely comprehensive and scholarly, giving a moving picture of accomplishment, probabilities and possibilities for America's vast economic and social potential. The briefer volume has been written with a simplified text, liberally illustrated by splendid picture charts. Thus it is hoped to place this study before a far wider audience than the original research could ever reach. Undoubtedly many a reader of "U.S.A." will want to turn to the original study for amplification of many points in the survey. He will find that Dr. Dewhurst's data and conclusions are a monumental record of the engineer's achievements.

It is evident that the secret of our spectacular war-time and peace-time production is the tremendous expansion of machine power. In 1944

U.S.A. turned out nearly 27 times as much in goods and services as was done in 1850, yet the labor force was only 8½ times as large. The difference is explained by the fact that 343 times as much mechanical energy was used in producing these goods. Dr. Dewhurst contends that over the long run the efficiency of the individual worker is a minor element in the productivity of the labor force. The fabulous increase in output per man hour was accomplished not by harder or more skillful efforts, but by constantly devising new and better machinery to augment human labor. He says that our accomplishments in the 1950 decade will depend more than anything else on the extent of further gains in productivity. Engineers know that the gain in output will be largely a measure of their ingenuity, plus the stimulus of an economic environment that will enable business to try new manufacturing ventures. The data in the basic study is largely based on dollar estimates of 1947 purchasing power. The price level has risen so that most of the figures would be about 8 to 10 percent higher in terms of today's prices. The reader should, of course, keep this in mind.

On the question of whether the great increase in the use of machines and mechanical power causes workers to lose jobs and thus creates technological unemployment, Dr. Dewhurst finds that it is only through technological disemployment that material progress is possible. With some costly and painful interruptions, it is true that "we have had our cake in the form of an expanding full employment and eaten it in the form of increased leisure in an ever-higher standard of living."

"Minerals have become our dominant source of work energy. In 1940 we used seven times as much mineral energy per man hour as in 1900, and 70 times as much as in 1850. By 1960, with minerals doing nearly 99 percent of our nonhuman work for us, we will be using over 100 times as much mineral energy per man hour as in 1850. It is in this phenomenal increase in the use of inanimate energy which more than anything else accounts for the high standards of living in the economic primacy of the United States in the modern world."

Dr. Dewhurst concludes that we ought to increase output for man hour during the next decade by approximate 18 percent. But he also adds that the net effect will be determined, as it has been in the past, by a multitude of actions and decisions on the part of individuals such as inventors, industrial managers, investors, workers and consumers. One can hardly refrain from adding that engineers should be included, for it is their technical skill

Unit construction—
Fit standard AC mounting

Now, with this modern, compact solenoid-type contactor . . . you'll no longer have the nuisance of drilling special holes for each component and furnishing special insulation.

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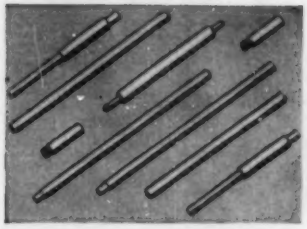

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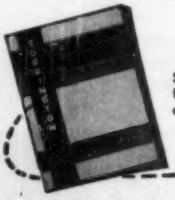

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that is the basis for our national output.

Accordingly, to readers who want a quick picture of our economy, "U.S.A." is heartily recommended. Those who find it valuable are bound to turn to "America's Needs and Resources" for the detailed analysis.

Engineering for Production

WALTER ERNST, *Director of Engineering, Commonwealth Engineering Company, 8½ x 11 in., about 125 pages. Published by Research Press, Inc. 137 N. Perry St., Dayton 2, Ohio. Plastic spiral binding, cloth board covers.* $10.

Not a textbook, but rather a fundamental reference book, "Engineering for Production" makes available to the design engineer in a highly practical form, design data and standards essential for properly engineered low cost design. The striking difference between this publication and the usual handbook is that "Engineering for Production" in addition to presenting the data also places a major emphasis on the methods and standards to be followed in putting the information on the drawing, in order to conform to standard practices so that the drawings will be "interchangeable".

The book is divided into twenty-seven chapters or sections. The first twelve chapters are devoted to engineering drawings, the subject matter covering drawing sizes and title block, material lists, execution of drawings, projections, sectional views, dimensioning, tolerances and fits, and the use of symbols. All of the material pertaining to symbols and drawing room practices conform to accepted American Standards Association standards. This will be found to be one of the very convenient and useful features of this publication because it gives to the engineer in one volume all of the recognized drawing room symbols including surface quality symbols, welding symbols, symbols for electrical components, piping symbols, standard symbols for hydraulic circuits for industrial equipment. Following the twelve sections on drawing procedures and drawing room standards, is a section on castings and forgings. This chapter not only gives a concise description of the different types of castings and forgings, but also includes a wealth of information on their design and dimensioning. Similarly in the presentation on forgings, includes brief data on parting lines, draft, fillets and radii and tolerances, the last being those recommended by the Drop Forge Association.

The chapter on metals and heat treatment covers both ferrous metals and non-ferrous metals. The tables

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PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS — A MAJOR IMPROVEMENT AT A MINOR COST

on the AISI and SAE alloys, nitralloy compositions, casting alloys, manufacturing tolerances of cold drawn bars and tubing and similar tables dealing with the non-ferrous alloys, are conveniently arranged for ready reference.

"Threaded Connections and Screw Thread Standards", includes tables on the American National Screw Thread Standard, tap drill diameters, limits for National Coarse and National Fine threaded members, Acme Threads, finished and unfinished bolt heads and nuts and similar data.

Twenty-five pages are devoted to a section on piping and tubing. More than half of the space is given to tables on standards covering flanges, fittings, piping and welded connections. Other chapters include packings and gaskets, mechanical parts such as springs, keys, gears, chain and belt power transmissions, and bearings.

In the forward of this book written by Arthur M. Greene, Jr., Dean Emeritus of the School of Engineering, Princeton University, he states:

"Engineering for Production" brings the whole engineering department to a common procedural basis so that drawings in form, contents and basic design data are interchangeable, no matter what the experience or the personal tastes of the engineer and engineering draftsman.

This book does to engineering drawings what interchangeable manufacturing in the shop has done for mass manufacturing.

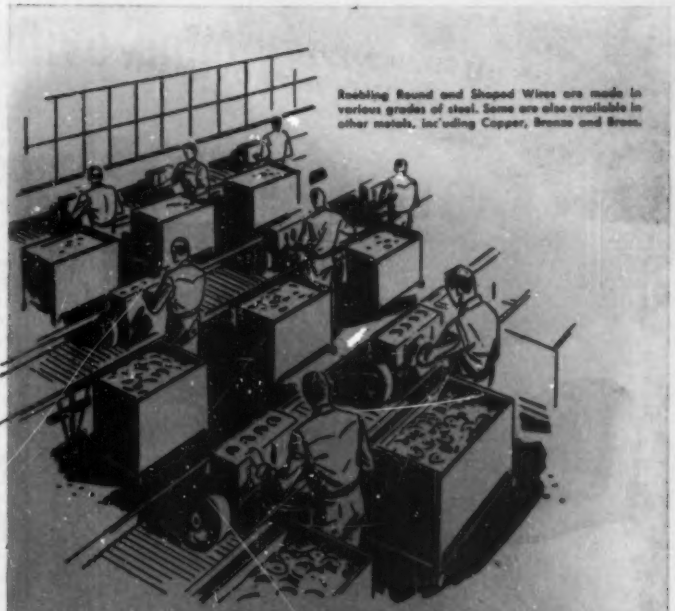
By this method, copies of drawings are equally useful in all departments of manufacturing, large or small—saves costs, saves errors, saves confusion—eliminates costly paper work—simplifies manufacturing procedure — in short, all members of the ball team play under the same ground rules."

U. S. Industrial Design 1949-1950

Produced by the Society of Industrial Designers, published by The Studio Publications Incorporated, 381 Fourth Avenue, New York, N. Y., 8½ x 11 in., 176 pages, price $10.00.

As is to be expected, this book has a format and layout that bespeaks the character of the profession of industrial design. Or more briefly, it is beautiful.

Every design engineer who is engaged in the development of products in which appearance is a factor, and that means practically every product, will find a wealth of inspiration in leafing through the pages of this book. In it are presented the outstanding recent designs of the members of the Society of Industrial Designers. The



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for Oil-Tempered Spring Wire

NO IFS, ANDS OR BUTS . . . production records show that Roebling Oil-Tempered Spring Wire cuts down machine stoppages and minimizes rejects for users everywhere. This is a *quality* wire. Every inch is alike in gauge and finish . . . absolutely uniform in mechanical and metallurgical properties.

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editorial committee of this book was under the chairmanship of Walter Dorwin Teague, the other members being Harold Van Doren, Robert Davol Budlong, Dave Chapman, Henry Dreyfuss, Montgomery Ferar, Hunt Lewis, Onnie Mankki, Stowe Myers, Carl Reynolds, and John Gordon Rideout. Philip McConnell, Executive Secretary of the Society of Industrial Designers, was managing editor.

In separate chapters, the book presents household equipment, equipment for personal use and recreation, commercial and professional equipment, transportation, industrial apparatus and machinery, packages and general identification programs, commercial interiors and exteriors, index of designers, and an index of business enterprises.

Each item of product presented is shown in beautiful photographs with a brief statement of the objective that was to be achieved, the requirements that the design had to meet, the name of the company for whom the design was produced and the name of the industrial designer. The text matter is primarily brief captions. In many instances, cost factors and performance records involved are mentioned in the book.

This splendid presentation will serve two worthy purposes. First, it will impress those industrialists and engineers who are not acquainted with the industrial design profession with the typical accomplishments of industrial design, and in that manner will contribute tremendously to a greater recognition of that profession. However, for the engineers of industry, and industrial executives this book will be both a great inspiration in its presentation of the design possibilities in every day products of the home and industry. The product designer will have to add the factor of beauty to his list of specifications. It will be one of the most important points remembered by the most important man—the customer with cash in his pocket.

Among the products that are presented are refrigerators, kitchen ranges, space heaters, furniture, air conditioners, fans, radios, television sets, kitchen equipment, scales, railroad passenger cars, automobiles, steamships, buses, portable saws, machine tools, agricultural equipment and also packages, apparel and personal items.

A chapter on "Commercial Interiors and Exteriors" although perhaps not a topic of prime interest to readers of PRODUCT ENGINEERING most decidedly visualizes the great possibilities in this field.

The Society of Industrial Designers can be highly commended for this splendid compilation and the quality of it as a work of art and inspiration.

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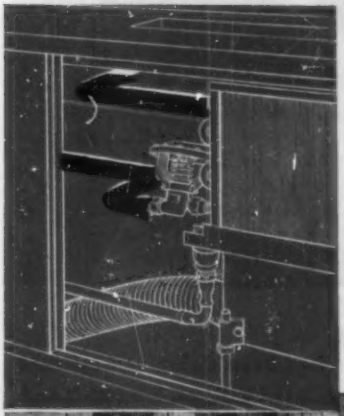
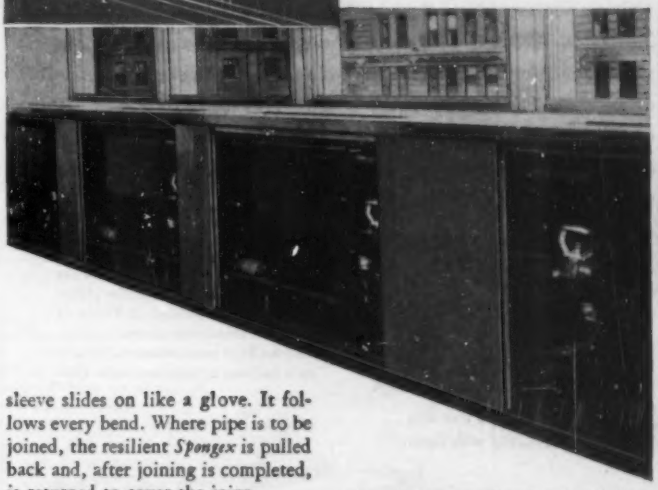


Air conditioning system installation by Kerby Saunders, Inc., at 100 Park Avenue, New York. George A. Fuller Company, General Contractor. Kahn & Jacobs, Architects. Jaros, Baum & Bolles, Consulting Engineers.

in this climate control development



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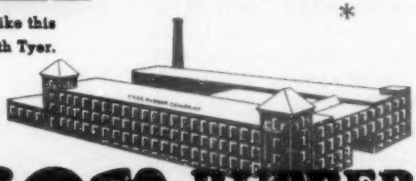

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January 10-12
SOCIETY OF THE PLASTICS INDUSTRY—Reinforced Plastics Division, Fifth Annual Technical Session, Cleveland Hotel, Cleveland, Ohio.

January 11-13
SOCIETY OF PLASTICS ENGINEERS—Sixth Annual National Conference; Hotel Carter, Cleveland, Ohio.

January 20
MALLEABLE FOUNDERS' SOCIETY—Semi-Annual Meeting; Hotel Cleveland, Cleveland, Ohio.

January 23-26
INSTITUTE OF AERONAUTICAL SCIENCES—Eighteenth Annual Meeting; Hotel Astor, New York City.

January 30—February 3
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Winter General Meeting, Hotel Statler, New York City.

February 20-21
SECOND ANNUAL PURDUE MATERIALS HANDLING CONFERENCE; Purdue University, Lafayette, Ind.

February 27—March 3
AMERICAN SOCIETY FOR TESTING MATERIALS—Committee Week and Spring Meeting; Hotel William Penn, Pittsburgh, Pa.

March 21-22
STEEL FOUNDERS' SOCIETY OF AMERICA—Annual Meeting, Chicago, Ill.

March 28-31
SOCIETY OF THE PLASTICS INDUSTRY—National Plastics Exposition; Navy Pier, Chicago, Ill.

April 4-7
NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Annual Conference and Exposition, St. Louis, Mo.

April 10-14
AMERICAN SOCIETY OF TOOL ENGINEERS—Industrial Exposition on Cost Cutting, Convention Hall, Philadelphia, Pa.

April 12-14
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, Hotel Statler, Washington, D. C.

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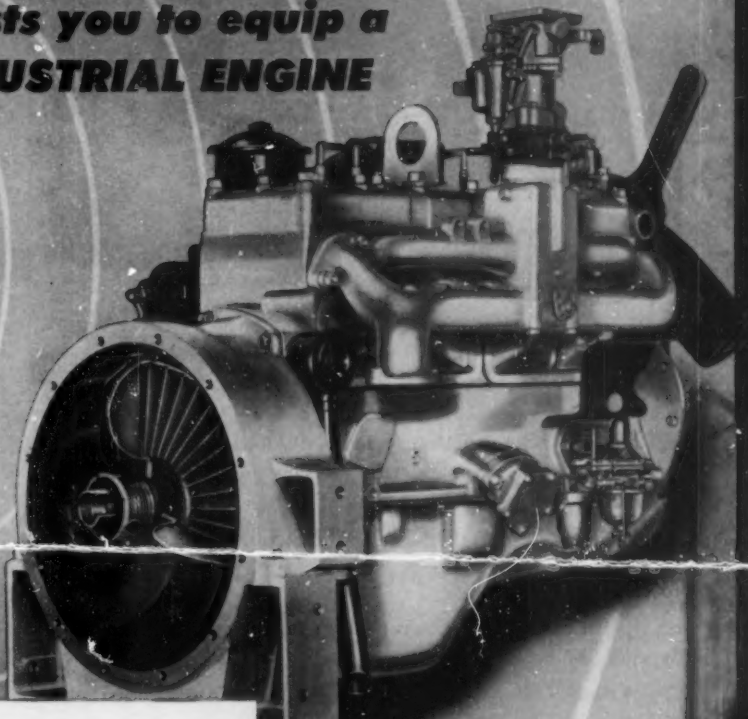

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OUR READERS SAY

Here's A New Way

To the Editor:

I would like to present a method of calculation whereby manufacturers of competitive hydraulic equipment can compile curves of pressure drop characteristics from room temperature data. This method will permit the designer to predict accurately the actual power available with any fluid, temperature, flow, or pressure.

—RALPH BOYER
Resale Products, Dill Mfg. Co.
Cleveland, Ohio

Ed.—We think that Mr. Boyer's article is important enough to print in full. The first part of his article gives some background information for those not too familiar with the subject.

Manufacturers of hydraulic equipment usually specify the pressure drop at a given flow when a certain oil is used at some definite temperature. What the pressure drop would be if another oil were used or if the piece of equipment were subjected to subzero temperatures is not specified. In most cases it is impossible for the designer to secure this information from the manufacturer.

Especially in aircraft, where a valve may be subjected to extremely low temperature or be many feet away from the pump, a designer only can guess at the actual power available. Efforts have been made to off-set this unknown loss by increasing the pump output pressure. Obviously, increasing the pump output pressure to compensate for the pressure drop losses in the valves and fittings will not result in an efficient system. Seldom are the pressure drop characteristics used as a criteria for the selection of hydraulic system components.

This condition is probably due to the fact that, as yet, no simple, accurate method has been presented for the evaluation of the pressure drop characteristics of competitive hydraulic equipment.

Friction factors for the pressure head losses in pipes carrying water have been experimentally established until the trade is able to select satisfactory components for any given system. The well-known curves indicate

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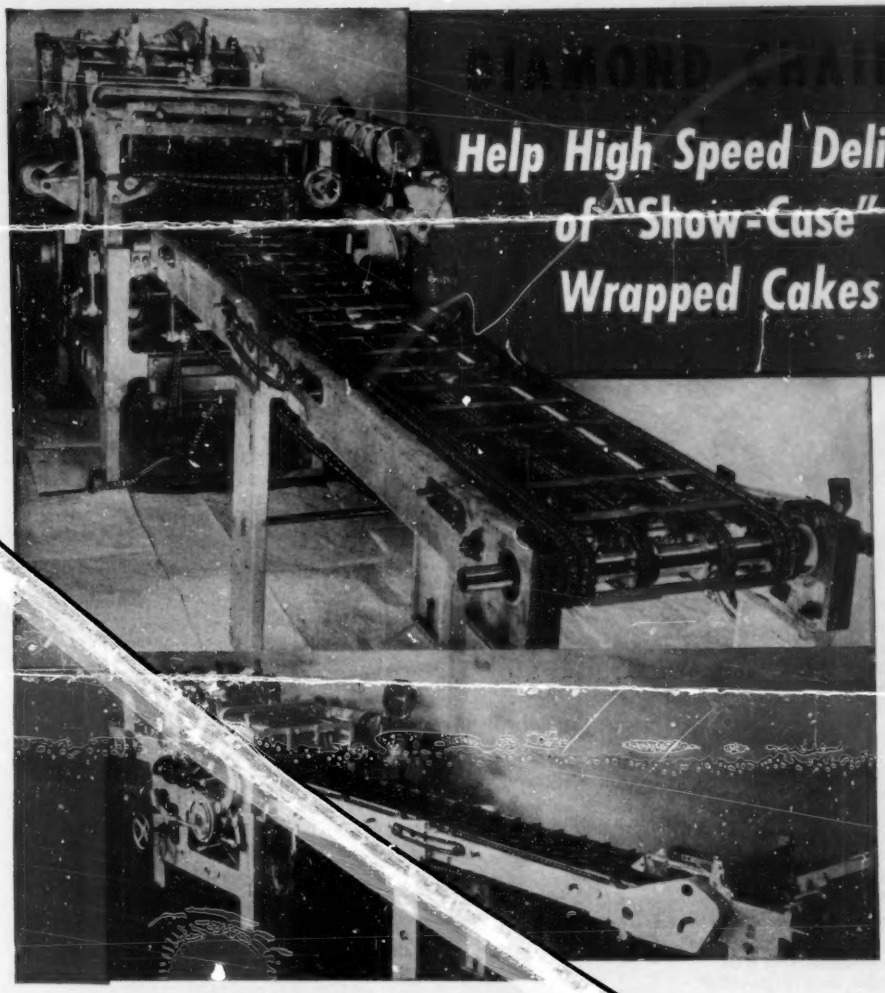

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the variation of friction factor with respect to the Reynolds number. However, a water system is comparatively simple due to the limited range through which the viscosity varies.

Considerable experimentation has been done with orifices measuring the coefficient of discharge versus Reynolds number. These coefficients have been established so accurately that orifice meters are now widely used. It has been proven that in a given orifice the coefficient of discharge will remain a constant so long as Reynolds number does not vary.

Most installations are not subjected to high temperature differentials, and Reynolds number is made to vary only by a change in velocity. However, a given value for Reynolds number may be achieved by varying either velocity or viscosity.

A given Reynolds number at room temperature with low velocity also may be achieved at low temperature with high velocities. The change is viscosity of the fluids permits like values to be obtained. Inasmuch as the Reynolds number is an abstract number, how it is achieved is of no consequence.

A typical Reynolds number versus coefficient of discharge curve for an orifice, is illustrated in Fig. 1. Portions of this curve are similar to curves of previous experimenters. The curve though the low values of Reynolds number is somewhat unusual. The low values would be present in a hydraulic system at sub-zero temperatures due to the extreme range through which the viscosity of most oils vary.

The curve in Fig. 1 was determined experimentally by two methods: First, by using oil at room temperatures and, second, by using oil at low tempera-

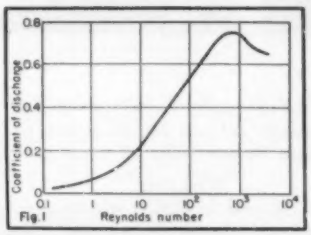

Fig. 1

tures. A major portion of the curve contains points established by both methods. The plotting of this curve by using oils of varying temperatures, hence varying viscosity, re-establishes the fact that in an orifice the coefficient of discharge is a constant for any one value of Reynolds number.

Knowing the geometry of the orifice and the viscosity of the oil, it is possible to read the curve of Fig. 1 and predict the exact pressure drop with

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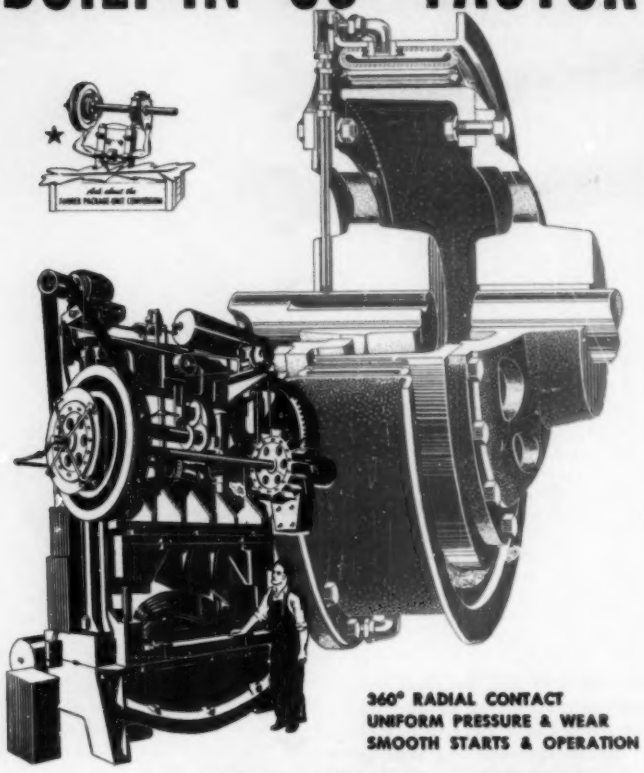

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any flow. It should be pointed out that this one curve can only be used to predict the pressure drop for this one orifice and no other.

To illustrate the procedure, assume it is desired to know the pressure drop when two gpm are forced through the orifice at zero deg F.

Orifice diameter = 0.0053 feet (d)
Viscosity = 0.0099 square feet per second (ν)
Velocity = 200 feet per second (V)

(I) Reynolds number $= \frac{d\,V}{\nu} = 110$

A corresponding value for coefficient of discharge from Fig. 1 is 0.55

Discharge = 0.0045 cubic feet per second (Q)
Orifice Area = 0.000022 square feet (A)
Coefficient of Discharge = 0.55 (C_d) from Figure 1
Gravity = 32 feet per second per second (g)
Head = Pressure in feet of oil (h)

Using the flow equation:

(II) $\quad Q = C_d A \sqrt{2\,g\,h}$

By substitution:

h = 2200 feet of pressure head
= 860 pounds per square inch pressure differential required.

The preceding discussion is applicable only to orifices where the geometry may be accurately measured. In the typical hydraulic valve it is practically impossible to determine accurate Reynolds numbers. Dimensions could be established arbitrarily and, if used consistently, the method could be used for predicting low temperature pressure drop from room temperature data. However, a curve thus plotted could not be used for comparing competitive equipment.

The above theory is based upon the plotting of the coefficient of discharge versus Reynolds number. The coefficient of discharge is determined from the flow equation:

(II) $\quad Q = C_d A \sqrt{2\,g\,h}$

(III) Or $\quad C_d A = \frac{Q}{\sqrt{2\,g\,h}}$

For any one valve the area of the restriction is a constant. Therefore, a curve plotted using the right hand term of the above equation as the ordinate in place of the coefficient of discharge would be equally representative. In order to use terms that are common to the trade the above term may be replaced with:

(IV) $\quad \frac{\text{Gallons per Minute}}{\sqrt{\text{Pounds per Square Inch}}} = \frac{gpm}{\sqrt{psi}}$

The Reynolds number is determined from the equation:

(I) $\quad$ Reynolds number $= \frac{d\,V}{\nu}$

(*continued on page* 202)

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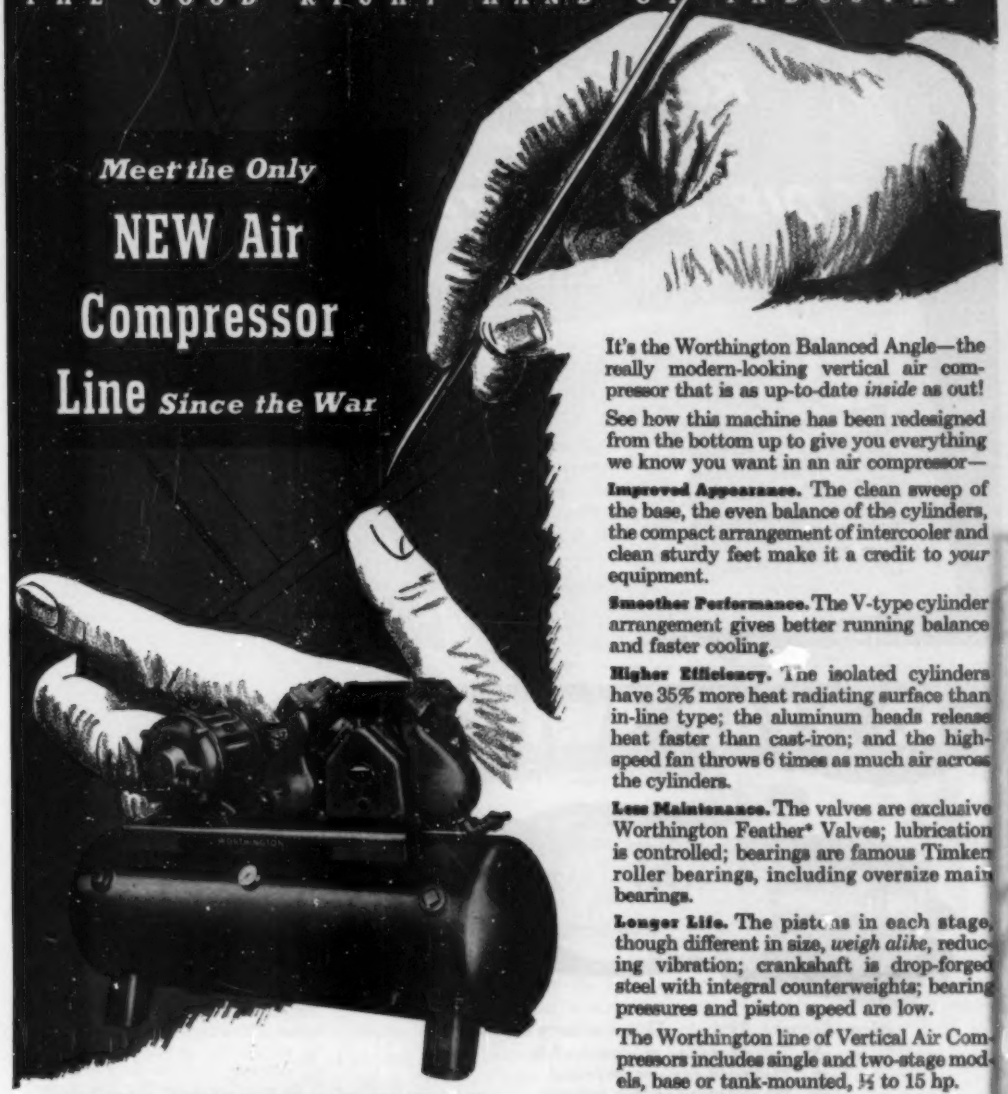

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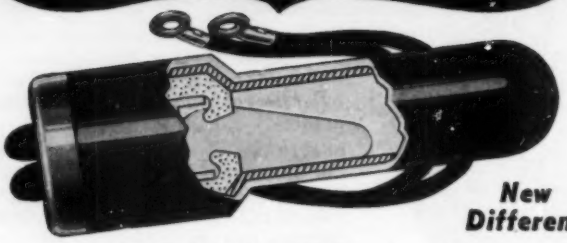

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(continued from page 200)

(V) Where: $V = C_d\sqrt{2gh} = \frac{Q}{A}$

(VI) And: $A = [0.7854d^2]$

(VII) Substituting: Reynolds Number

$$= \frac{Q}{\nu} \quad \frac{1}{0.7854d}$$

For any one valve the diameter of the restriction is a constant. Therefore a term similar to the Reynolds number, which we will call a Reynolds number Equivalent (RE), will be expressed simply as:

(VIII) $RE = \frac{Q}{\nu}$

(IX) $RE = \frac{Epm}{\nu}$

From the above it appears, that in place of the usual curve of coefficient of discharge versus Reynolds number, that a curve of gallons per minute divided by the square root of the pressure versus gallons per minute divided by the viscosity would be equally representative, and yet it would contain no errors due to the inaccurate determination of Reynolds number.

Fig. 2 shows curves thus plotted for two hydraulic valves. The curves were obtained at room temperatures and

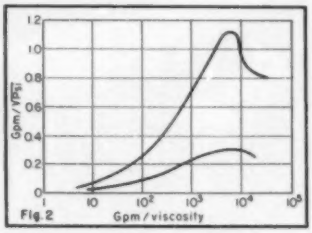

Fig. 2

checked at low temperatures. By inspection, the valve represented by the lower curve will offer the greater resistance to flow.

Geometrically similar valves would plot as a family of curves. For a given flow and viscosity the value of the abscissa would be the same for all the valves. However, the larger the valve the greater the ordinate value would be, indicating less resistance to flow.

To read the curve for low temperatures, it is only necessary to know the viscosity of the oil at the particular temperature. For any one flow, low temperatures and high viscosity will decrease the abscissa value; low viscosity will move the abscissa value to the right.

The curves represented in Fig. 2 may be compiled entirely from room temperature data. The small values are obtained by extremely low pressure heads (as low as one-eighth inch). Inasmuch as room temperature data may be compiled so accurately, curves

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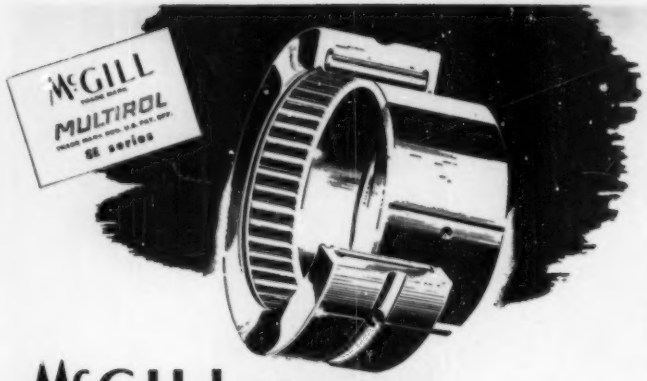
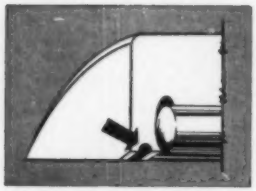


McGILL design
provides EXTRA oil seal protection



Extra protection against destructive foreign particles is provided by this lubricant-retaining groove, built into the inside diameter surface of the roller retaining-end shoulder. The ring of lubricant, held in this groove, acts against the inner race O.D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the rounded end of the roller. Acting as a lubricant reservoir, this provides Multirol SE Series bearings with an extra margin of protection against neglected or delayed lubrication.

The increased life and lowered maintenance costs of Multirol bearings are accounted for by these built-in features, plus such design factors as greater load capacity and the elimination of loose or welded-in retaining rings. Multirol SE Series bearings, used with or without inner raceways in standard sizes of 5/8" to 9¼", are used extensively in machine tools, pumps, polishing machines, presses, power shovels, etc. — giving users a high degree of precision performance and longer bearing life.

Why not consult McGill engineers for helpful recommendations in applying these benefits to your product? Write McGill Mfg. Co., Inc., Bearing Division, 201 N. Campbell St., Valparaiso, Indiana. Ask for Bulletin SE-47.

McGILL
TRADE MARK
precision bearings

thus plotted will be more representative than actual low temperature tests.

Since the Reynolds number has been eliminated with its inherent errors, competitive equipment may be evaluated accurately by visual inspection of their respective curves.

Use of the above method will eliminate the necessity for large, costly refrigerators to conduct low temperature tests. Malfunction, cyclic time, and similar tests may be conducted in the small inexpensive dry ice (CO_2) refrigerators. This method will permit even the smallest manufacturer to conduct complete tests and submit curves that may be compared accurately with similar curves compiled from competitive equipment. The designer, also, will be able to predict accurately the power available regardless of the manufacturer, type or size of valve, fluid, or temperature.

Erratum

To the Editor:

In the August issue of Product Engineering, page 149, in the "Nomogram for Determining Length of Wire on a Magnetic Coil", you made an obvious error in one of the scales. The small nomo for mean turn at the lower right, middle scale, is marked wrong from the number 8 out to the right end.

—CARL P. NACHOD
Louisville, Ky.

Ed—You are right, Mr. Nachod, we're wrong. Since this is such an obvious error in dividing the scale, we hope that interested readers recognized the error, and took it into account when using the nomogram.

Comment and Rebuttal

To the Editor:

I would like to point out one of your recent articles (Journal Bearing Lubrication, October issue, page 96) as an example of the dangerous practice of over-simplification. I feel that this article, with an important subject, lucid style, and excellent layout, is weakened considerably through the use of untrue generalizations.

I'll list the points that I believe to be incorrect or oversimplified:

(1) There is no nomenclature, and not all the equations are entirely between dimentionless parameters.

(2) In the middle of the third column, page 96, "Frictional resistance caused . . . seizure of the surfaces." I must protest against this over-simplifying, purely-mechanical, project-and-tear explanation of friction, as contrary to the true facts. Fine polished surfaces show higher friction than rough-ground. Friction is as much or more

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Appliances need good motors to give dependable service. Years of engineering and manufacturing experience have put top quality into Delco appliance motors.

But today, appliance manufacturers need even more than that. Fast changing markets often mean changes in motor specifications or delivery dates. Because Delco is organized to meet these requirements, manufacturers get what they want—when they want it—changes included.

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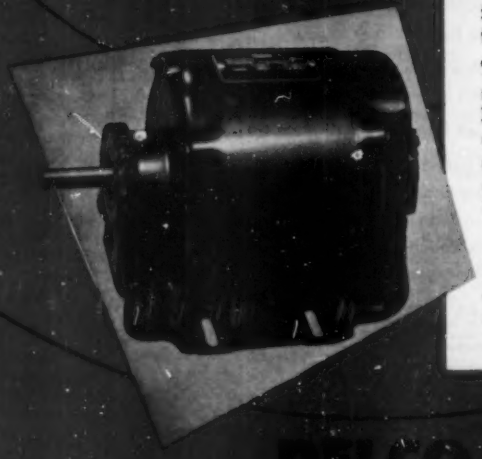

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a chemical as a mechanical phenomenon.

(3) Page 98: All of this mathematical information is useless to the reader unless he studies elsewhere because units of measure are not stated. For example, to say that μ is the "Viscosity" tells us nothing; there are a half-dozen ways of measuring Viscosity; which is used here?

(4) Middle of the third column, page 98: "friction coefficient would be a straight line (called Petroff's line) when plotted against . . . as in Fig. 5." The ordinate in Fig. 5 is $(r/c)\ f$, not f. We could divide the ordinate by (r/c) and likewise the abscissa, thus obtaining the same straight line, but the abscissa algebra and ordinate algebra would then be quite a departure from that shown in Fig. 5.

I hope these comments will point out the type of over-simplications that sometimes ruin an otherwise excellent article. —H. S. B.

New York City

Ed—We gave the authors, Mr. A. E. Roach and Mr. C. B. Griffin, a chance to answer the above points. The following rebuttal will give the only gist of their answer. We have shortened their reply to answer only the questions raised, and will list the rebuttal, point by point, to reply to corresponding questions. Here are the answers:

(1) The specification of units is not necessary except in the case of non-homogeneous equations. Since any general physical equation is homogeneous, we may use any units we choose so long as we are consistent. For example, equation 5, in the article, remains perfectly true whether we measure length in inches, force in pounds, and time in seconds, (in which case μ is in units of lb-sec per square inch, N is in reciprocal seconds, D is in inches, p is in psi, and h is in inches), or whether we measure length in feet, force in pounds and time in hours. The equation would still be true if we measured length in furlongs, force in kips, and time in fortnights.

With regard to the specification of units in connection with the graphs, it is only necessary to point out that these are graphs between non-dimentional parameters to which any consistant system of units can be applied. This fact is pointed out in the caption on Fig. 3 and is further explained at the bottom of column 1, page 98.

(2) If the welding-tearing-plowing concept of dry friction is contrary to the true facts, then research workers in this field are pursuing an illusion. The original experimental work leading to this concept was carried out by Bowden and his associates at Cambridge University. There are many easily

Interested in Cylinder Controls . . .

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★ FOR DIRECT CONTROL OF SMALL CYLINDERS

★ FOR AUTOMATIC CONTROL OF LARGE CYLINDERS

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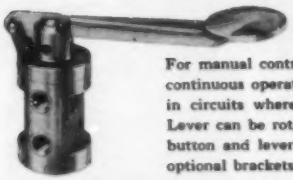
Ideal for automatic or semi-automatic control . . . A 3-way valve with spring-loaded roller actuated by straight line or rotary cam . . . Roller can be rotated 90° from position shown.

PUSH BUTTON OPERATED

Another compact 3-way Hanna Pilot Valve with push-button operation . . . excellent for control of panel operations—or where guards are used around valve to prevent accidental operation.



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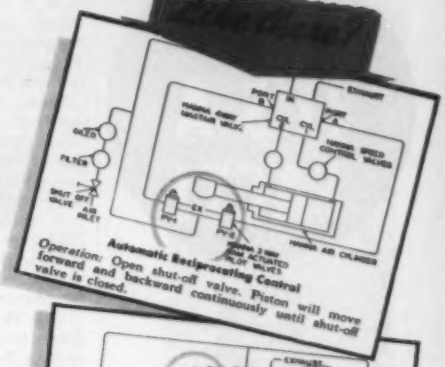
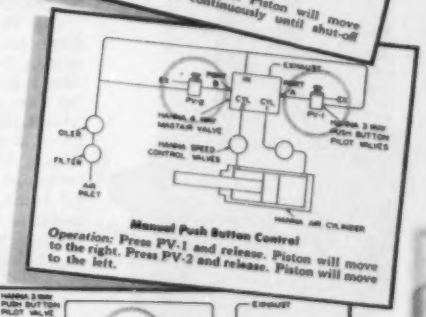
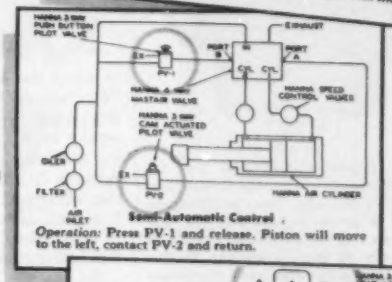
For manual control on fast, repeating and continuous operations . . . Efficiently used in circuits where safety is a factor . . . Lever can be rotated 90° . . . Cam, push-button and lever-operated valves all have optional brackets for side mounting.



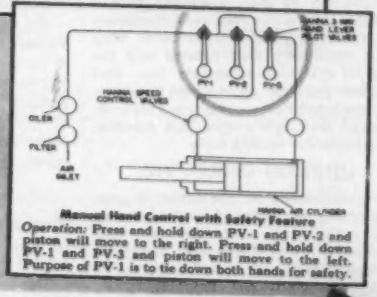
Automatic Reciprocating Control
Operation: Open shut-off valve. Piston will move forward and backward continuously until shut-off valve is closed.



Manual Push Button Control
Operation: Press PV-1 and release. Piston will move to the right. Press PV-2 and release. Piston will move to the left.



Semi-Automatic Control
Operation: Press PV-1 and release. Piston will move to the left, contact PV-2 and return.



Manual Hand Control with Safety Feature
Operation: Press and hold down PV-1 and PV-2 and piston will move to the right. Press and hold down PV-1 and PV-3 and piston will move to the left. Purpose of PV-1 is to tie down both hands for safety.

FOOT OPERATED

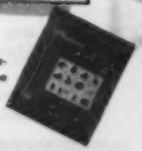
Hanna 4-way Foot-operated Pilot Valves are available in single and double-pedal units for convenient, hand-free control of cylinders. The single-pedal valve is shown.

MASTAIR

Hanna 4-way Mastair Valve . . . A balanced spool type valve controlled by one 4-way or two 3-way pilot valves for automatic control of large cylinders.

Send for Catalog

New Hanna Valve Catalog No. 251 has illustrations, specifications and full details on the complete Hanna Valve line.



Hanna Engineering Works

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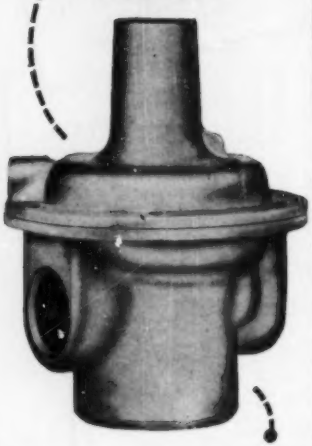

The gas regulator illustrated was die cast from aluminum for the Detroit Gas Regulator Company. The specifications required a pressure regulator for gas appliances that must be leak proof and accurately control pressure to the burner. Litemetal's precision aluminum die casting solved this problem. Very little machining was needed and the overall cost was extremely low. Just another example of meeting a manufacturer's problem and reducing his costs through fine, lightweight and durable, aluminum die casting by—

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an organization of specialists — men thoroughly experienced in the casting and machining of magnesium and aluminum alloys — the new metals of structural design.

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available references to support this concept.

With regard to the alleged higher friction of fine-polished surfaces than rough-ground surfaces, this is a popular fallacy for which there does not seem to be a thread of conclusive experimental evidence. In fact, experiment indicates the contrary to be the case. Rough-ground surfaces may have a lower friction coefficient than fine-ground surfaces when the surfaces are contaminated by oxide films, moisture, oil films, and the like—but we are talking about dry friction, which is a different thing entirely.

(3) For the answer to this question, see comments under (1), above.

(4) This argument about the ordinate and abscissa in Fig. 5 is true enough, but it does not follow that there is anything inconsistent or illogical about this mode of discussing the friction coefficient. Sommerfeld, (in his *Zeitschrift fur Mathematik und Physik*, 50, 1904, 97-115) in his pioneer analysis of the complete journal bearing showed that the friction coefficient is given by

$$\mu N/p = (c/r)^2 \frac{(2+n^2)\,(1-n^2)^{1/2}}{12\,\pi\,2n}$$

Hence, $(r/c)\,f = \phi\,(n)$

and $(r/c)^2 \mu N/p = F\,(n)$

in which the symbols ϕ and F denote "functions of." This is the reason for retaining (r/c) in the parameters, and results in the convention of expressing the friction coefficient of a hydrodynamic bearing as $(r/c)f$. A further advantage of this notation is that it permits us to use the same abscissa in both figures 3, and 4, and thereby facilitating cross-checking.

Solving the last two equations for various values of n between the limits $n = 0$ and $n = 1$, and plotting the values of $(r/c)^2\,\mu N/p$ so obtained as abscissa against corresponding values of $(r/c)f$ as ordinates, we obtain a curve very similar to the experimental curve, in Fig. 5 of the article.

Here's a Hot Torch

To the Editor:

I've heard something recently about a new electronic torch with extremely high heat ranges. What can you tell me about it?

—D. COTTON
Savannah, Ga.

Heat sufficient to melt tungsten, which melts at 3,370 C can be obtained with a new electronic torch revealed by the General Electric Research Laboratory. Device utilizes extremely high-frequency radio waves with such

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REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

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½ to 40,000 HP
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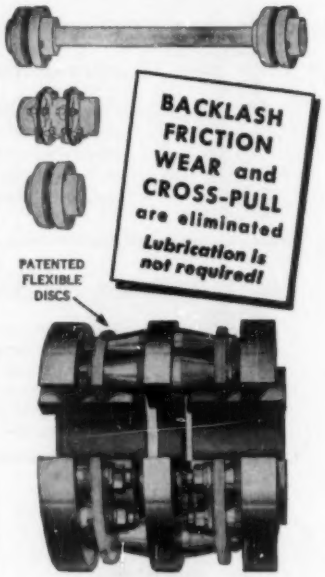

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NO MAINTENANCE PROBLEMS.
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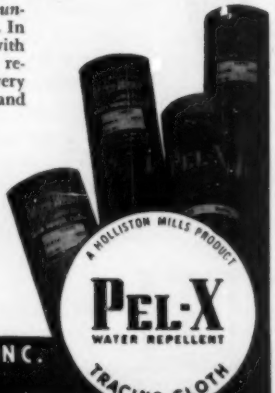
This is proof that PEL-X can do everything as well as any other tracing cloth and some things better.

Find out for yourself just how good PEL-X really is by trying it on your drawing board. Put it to any test against any competitive tracing cloth and compare the results. We're sure you'll want to switch to PEL-X. Write for generous sample. •Name on request.



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gases as nitrogen or carbon dioxide fed past the discharge arc.

As described by Dr. J. D. Cobine, the heart of the torch is a tube known as a magnetron that produces radio waves of 1,000,000,000 cycles per second. Leading from the tube is an antenna made of two short metal cylinders, one within the other. A high frequency arc formed at the end of the antenna breaks down the molecules of different gases flowing past the arc, resulting in a jet about 9 in. long.

The high temperatures produced on any surface placed in the jet are obtained from the heat generated by atoms joining together to reform molecules. The jet itself is not necessarily hot.

Erratum

To the Editor:

In the article "Evaluating Load Ratings of Annular Ball Bearing" appearing in your December, 1949 issue, the equation given in paragraph 11, page 90, for P_r when $V X F_r + Y F_a$ $K Z D_a^2$ should read

$$P_r = \frac{(V X F_r + Y F_a)^{3/2}}{(K Z D_a^2)} (V X F_r + Y F_a)$$

—M. T. M.

Ed.—Thanks for catching our error.

How About Photo Copy And Equipment?

To the Editor:

. . . what new information do you have on photographic copying equipment? . . .

—W. D. E.
New York

A compact photographic copying device, called the Contoura, takes the writer's cramp out of scholarly research. The invention is an eight-by-ten-inch lightweight metal case, two and a quarter inches deep—just thick enough to contain a layer of six matched electric light bulbs. The bottom consists of a light equalization mask and a translucent inflated cushion.

The special mask is the secret of the Contoura's compactness. Without it, the lights within the device could not be brought so close to the subject matter being copied. The cushion allows the device to photograph material on the "curve" of a page. It holds a special "slow" photographing paper with equal pressure against all parts of the area being photographed and can be inflated or deflated as needed.

With conventional "wet" processing, the Contoura produces reversed

Steel-Weld FABRICATION

Here, in this marine steam engine frame which was formerly produced in casting form, is another excellent example of fine workmanship in Steel-Weld Fabrication. It is typical of thousands of heavy machinery parts and assemblies produced by Mahon for manufacturers throughout the country. Whatever your requirements may be, regardless of size or weight, you will find in the Mahon organization an unusual source for welded steel in any form . . . a source with complete production, handling, and machining facilities, backed by a staff of competent design engineers and craftsmen from whom you may expect a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

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Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

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HOOVER BALL BEARINGS
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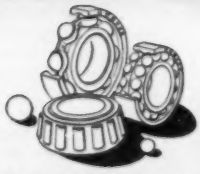
In bearings engineers judge quality by quietness. They know that the quietest running bearing makes the best showing in the battle against friction . . . and has the longest life. Hoover Ball Bearings with honed raceways . . . an exclusive Hoover feature . . . are the world's quietest ball bearings. This fact has been proved by sound testing on a special radio device. In comparison with four other leading makes, Hoover won hands down! The secret of Hoover leadership in quietness is the Hoover honed raceway. Mechanically honed on special machines, Hoover makes available, at reasonable cost, a ball bearing perfection previously found only in hand-honed laboratory samples. Write, on your letterhead, for a copy of the Hoover Engineering Manual.



The Aristocrat of Bearings

Hoover Ball and Bearing Co., Ann Arbor, Michigan

HOOVER
AMERICA'S ONLY BALL BEARING WITH HONED RACEWAYS

negative prints. Positive prints can be obtained by re-copying the material with the device.

To operate the unit, the user places a piece of the photo paper on the material selected, puts the device on top of it, and presses a pushbutton light switch "on" and "off". Timing does not have to be exact and the operation can be performed in normal light. The exposed paper is then developed in the conventional manner.

While the device is in operation, the light from the six internal bulbs passes through the equalization mask, the translucent cushion and the printing paper. It is reflected back onto the photo paper by the "white" of the page; the black print absorbs the light, producing the negative reproduction.

Our Mistake

To the Editor:

In the December 1949 issue of PRODUCT ENGINEERING, on page 163, in the article "Fundamental Frequencies of Bars With Concentrated Central Masses", there is given the formula,

$$f = 12.55\, P^{3} \frac{EI}{WL^{3}}$$

The results of this formula are so far from agreement with others that it seems to have been written incorrectly. We believe that the intended formula must be,

$$f = 12.55\, P^{3} \sqrt{\frac{EI}{WL^{3}}}$$

We would appreciate learning whether or not our interpretation is correct.

—GILBERT HILL
L.A.B. Corporation

Ed—You are perfectly correct Mr. Hill. This was an unfortunate error on our part.

More New Appointment News

To the Editor:

We now have a new Commissioner of Patents, and I think this information should be published. Why not publish all the names of those newly appointed to fill positions of interest to engineers?

—MILLARD WAGNON
Brooklyn, N. Y.

Ed—John M. Marzall, Chicago patent lawyer, has been appointed by President Truman to succeed Lawrence C. Kingsland as Commissioner of Patents. The out-going head has been instrumental in streamlining many of the office's operations during the last three years.

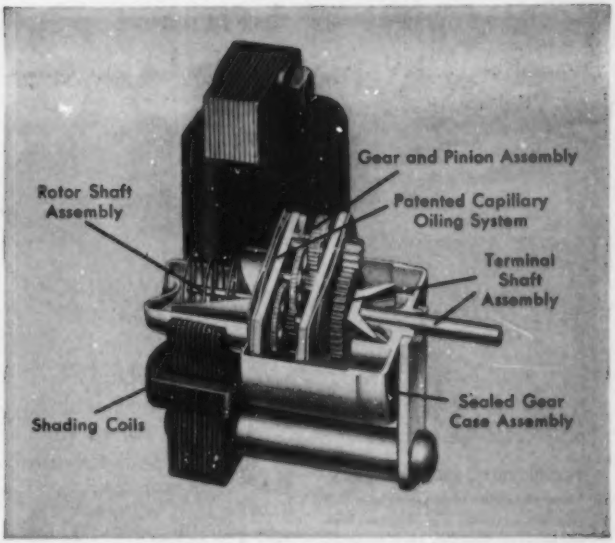
In one of his last official acts, Kingsland announced that, for the first time in years, the Patent Office is disposing

Floating Rotor Prevents Motor Lag or Slippage

Specially designed light-weight rotor virtually floats in a rotating magnetic field. Rotor shaft rotates on a film of oil . . . no metal to metal contact with its bearing. These features, together with capillary oiling system, account for the fact that *All Telechron Timing Motors Are Instantly, Constantly Synchronous.*

That is why so many designers concerned with split-second timing or control of light-weight moving parts specify Telechron motors.

If you have such a problem, why not turn it over to a Telechron Application Engineer? Drawing on the experience that makes all electric timing possible (virtually all frequency-controlling master clocks in power stations are made by Telechron), he can probably show you how a standard Telechron motor can do your job, too. Consult him early in your planning for big savings in time and money. Use handy coupon below for complete data. TELECHRON INC. A General Electric Affiliate.



Telechron Type B Synchronous Motor. For medium duty purposes such as switches, recording-controlling mechanisms and other control equipment. Other models with lower or higher torque for light or heavy duty applications.

Typical of Telechron Type H3 light duty motor applications is this 60-minute timer, the purpose of which is to operate a switch or signal at the end of a pre-selected period.

Practically all time-stamps and recorders employ Telechron Type B motors to operate their timing mechanisms. Obviously a motor that is instantly, constantly synchronous is needed for such applications.

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ALL TELECHRON TIMING MOTORS ARE INSTANTLY . . . CONSTANTLY SYNCHRONOUS

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Timers	☐	Other (please fill in)	
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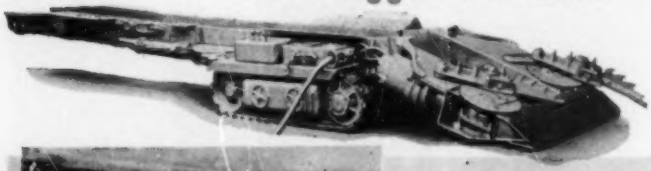
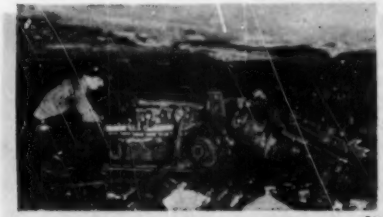
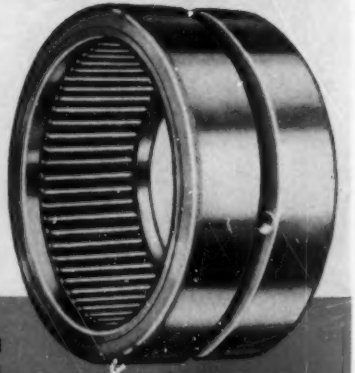




JOY JUNIOR LOADERS find ORANGE Roller Bushings "best suited for the limited space available"

JOY JUNIOR LOADERS are specially designed for thin seam operation in coal mines, where every inch of space is at a premium. The entire unit is only 26" in overall height, yet it loads from ¾ to 1¾ tons per minute. Orange Roller Bushings are installed in the conveyor hinge section and were selected as "the bearings best suited to carry the high loads in the limited space available". Joy Manufacturing Company has used Orange Roller Bushings since 1935.



ORANGE ROLLER BUSHINGS

HIGH loads, severe service, limited space . . . this combination is one of the most persistent problems facing design engineers. Ease your problem in the matter of bearings, by relying upon Orange Roller Bushings for highest anti-friction protection, under heavy loads, in small space.

Orange Roller Bushings are precision bearings, made to closest tolerances. Roller clearances are held to a minimum, resulting in closer internal running clearances. This reduces possibility of misaligned rollers. Orange Roller Bushings are quiet, smooth-running . . . equally efficient in high precision machine tools or high-stress, high-load equipment.

Write for Engineering Data Book showing design, sizes, capacities, installation data, etc. Our engineers are glad to assist on any bearing problem.

ORANGE

ORANGE ROLLER BEARING CO., INC.
561 Main Street, Orange, N. J.

of applications for patents at a rate faster than they are being received. For the fiscal year ended last June 30, applications were 66,292, disposals were 67,935 and patents issued were 30,564. In the previous fiscal year, the record was: applications, 73,385; disposals, 46,910; and issues, 21,515.

Kingsland said that as of mid-October, there were 137,540 cases awaiting action, against 146,972 at the same time last year. He said the present record is the result of the approximate completion of the postwar rebuilding of the staff and the completion of training of new examiners.

Where Can I Get It?

When requesting information, please give full specifications so that we can make an intelligent answer. We get a great number of requests like "Please tell me where I can buy conveyor chains." This type of request means very little and we can seldom point out the best manufacturer of the particular type of conveyor chain this reader needs for his special application. So send us your request but please make them specific. Help us to help you—ED.

Diaphragm Air Cylinders

To the Editor:

We are in urgent need of a Diaphragm Air Cylinder. If you have any information on this type of Cylinder please send it to us as soon as possible.

—ROBERT A. CHRISTY
Christy Eng. & Development Co.

Ed.—There are so many variables in selecting cylinders for a particular application that it is hard to point out exactly who you should contact. We suggest that you write the Westinghouse Air Brake Company in New York and the Bellows Co. in Grand Rapids.

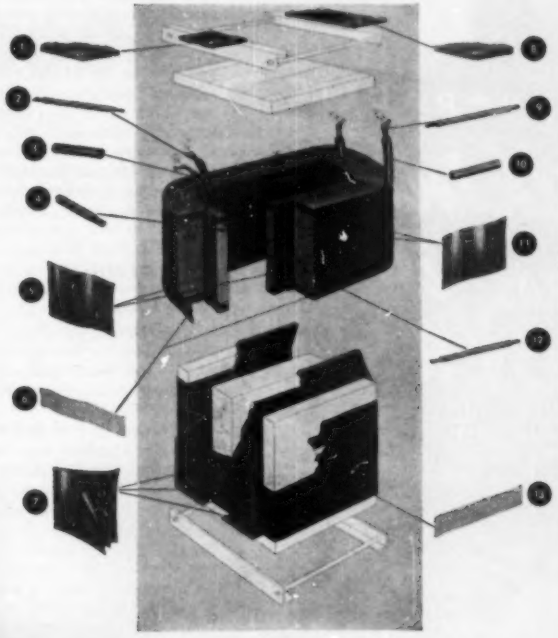
Belleville Springs

To the Editor:

I found in a copy of PRODUCT ENGINEERING of February 1940 an article entitled "Belleville Springs," by Mr. William Wallace Boyd. This proved to be of great interest to me, for with a definite modification, I believe that springs of this type might solve a problem that interests me greatly.

Would you please supply the fol-

FIBERGLAS INSULATED DRY-TYPE TRANSFORMER



KEY

1. Primary Terminal Block (Laminate reinforced with Fiberglas fibers.)
2. Primary Lead Wire (Covered with Fiberglas yarns.)
3. Primary Lead Wire Protection (Saturated sleeving braided of Fiberglas yarns.)
4. Primary Coil Magnet Wire Insulation (Made with Fiberglas yarns.)
5. Sheet Insulation between Primary and Secondary Coils (Cloth and mica combination sheet or varnished cloth made of Fiberglas yarns.)
6. Coil Binding Tape (Untreated tape made of Fiberglas yarns.)
7. Ground Insulation (Mica combined with cloth made of Fiberglas yarns.)
8. Secondary Terminal Block (Laminate reinforced with Fiberglas fibers.)
9. Secondary Lead Wire (Covered with Fiberglas yarns.)
10. Secondary Lead Wire Protection (Saturated sleeving braided of Fiberglas yarns.)
11. Layer Insulation in both Primary and Secondary Coils (Varnished cloth made of Fiberglas yarns.)
12. Secondary Coil Magnet Wire Insulation (Made with Fiberglas yarns.)
13. Core Binding Tape (Untreated tape made of Fiberglas yarns.)

HOW TO USE FIBERGLAS* GLASS-BASE ELECTRICAL INSULATING MATERIALS IN DRY-TYPE TRANSFORMER DESIGN

Here's why Fiberglas glass yarns, used in the applications shown above, help design engineers produce better dry-type transformers. Fiberglas yarns . . . have excellent heat resistance, plus good thermal conductivity . . . have high tensile strength, plus lasting toughness . . . resist moisture . . . are light in weight and are compact enough to assist in reducing size and lowering production costs.

If you produce small, lightweight transformers—and must consider a high safety factor against fire—consider Fiberglas glass-base insulating materials.

Ask for your copy of our new catalog describing these materials today. Write Owens-Corning Fiberglas Corporation, Textile Products Division, Dept. 807, 16 East 56th Street, N. Y. 22.

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STANDARDIZED FOR LOWER COST, QUICKER DELIVERY! — Pneumatic cylinders are offered in 10 standard sizes, from 1" to 12", and 6 mounting styles. Hydraulic cylinders are offered in 12 standard sizes, from 1" to 8", and 11 mounting styles. Any length stroke; single or double end rods; adjustable cushions for head end, rod end, or both. Many combination mounting styles. Also "Hy-Power" hydraulic cylinders in sizes from 2" to 7¼" for pressures to 5,000 psi.

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ENGINEERING RECOMMENDATIONS — Let Hannifin engineers help you get the BEST solution for your cylinder problems. See your local Hannifin representative, or write.

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Bulletin 110 (Left)—"HANNIFIN HYDRAULIC CYLINDERS." 52 pages of useful specification and engineering data complete with illustrations, drawings, and dimensions.

Bulletin 210 (Right)—"HANNIFIN PNEUMATIC CYLINDERS." 48 page bulletin featuring Hannifin Series "R" and Series "LW" cylinders. Dimensions, tables, engineering data.

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PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES

lowing information? (1) Who makes Belleville Springs? (2) Are they a patented article? —J. B. REIM
Toronto 3, Canada

Ed—These Belleville springs are not a patented article as such, and are made by a number of manufacturers. These manufacturers should give you all the contacts you need: Wallace Barnes Co., Division of Associated Spring Corp., 100 Wallace St., Bristol, Conn., M. D. Hubbard Spring Co., 221 Central Avenue, Pontiac, Mich., Barnes-Gibson-Raymond, Division of Associated Spring Corp., 6406 Miller Avenue, Detroit, Michigan, Raymond Mfg. Co., Division of Associated Spring Corp., 310 South Center St., Corry, Pa.

Electric Coils

To the Editor:

Your "Where can I get it" column, appearing in the November 1949 issue of PRODUCT ENGINEERING, may be a solution to a problem we have of this nature.

We would like to find a source of supply for standard stock sizes of ordinary multilayer winding electrical coils. The quantities we desire will probably not exceed one hundred units on the initial order. It is essential, however, that they be available without the necessity of supplying detailed specifications or paying a set-up charge. These coils are intended for use in ordinary iron circuits which will be designed around coils most readily obtainable. The desired coils should approximate the following specifications for our purpose: Form Factor—Cylindrical; I D — 1" to 2"; O D — 2" to 4"; Length — ½" to 1"; Wire size — No. 20 to No. 40 AWG.

We will appreciate any assistance you can render us in locating a suitable supplier for these items.

—W. M. PIPER
National Bureau of Standards

Ed.—This type of coil is seldom carried as a stock item. They are usually made to meet customers specifications. Here are two manufacturers who should be able to make what you need: Freed Transformer Co., Inc., 1736 Weirfield Street, Brooklyn, New York and United Transformer Inc., 150 Varick Street, New York City.

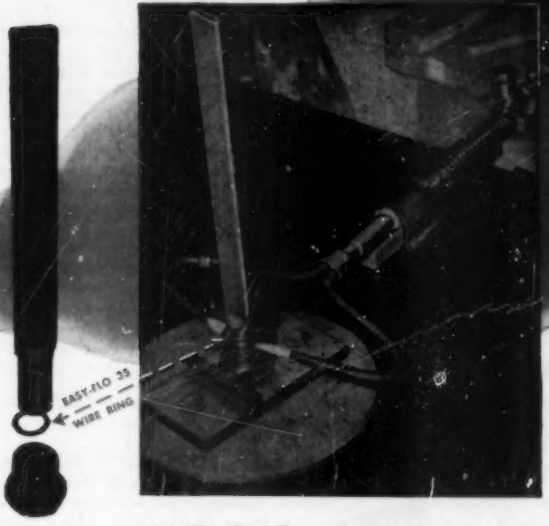
Heat Resistant Paint

To the Editor:

Would you please advise us as to where we might obtain a small sample of the high heat resistant Butyl Titanate paint reported in the February issue

They STEPPED-UP Production 300% — with EASY-FLO

EASY-FLO makes it simple for an experienced hand with an oxyacetylene torch to turn out a surprising volume of metal joining. It's this silver brazing alloy's combination of low-working temperature, exceptional fluidity and instant neous penetration that does it. Even so, output can be considerably increased, and torch brazing made so simple that practically anyone can do it. All it takes is a little ingenuity—such as was displayed by the engineers of Knight Rebound Controllers, Ltd., of Hamilton, Ont., when they had to speed up their production of immersion type water heaters. They figured out a simple procedure and a home-made set-up that reduced the actual brazing to a foot pedal proposition and stepped up production 300%. The pictures tell the story.



...for fast joining of the heater parts—a copper tube and brass bushing—and the ring of EASY-FLO 35 wire used to join them. Joint areas of parts are covered with Easy-Flo. Then, assembled parts, with the EASY-FLO 35 ring around the tube and resting on the bushing, are placed on turntable between horns of the 2-tipped torch. Operator then steps on pedal which lights torch from a pilot and starts turntable motor. That's all there is to it. Actual brazing time is about 1 minute.

FIND OUT where and how EASY-FLO low-temperature silver alloy brazing can speed up production and cut costs for you. Write today, for Bulletins 12-A and 15.

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SUPER ACE GRADE—one of the many formulas of Ace Hard Rubber available for molded and extruded machine parts, has a tensile strength exceeding that of most plastics, and high impact strength, too!

Even more important than strength is the *durability* of hard rubber—its unusual toughness, high abrasion-resistance, excellent resistance to water, acids, alkalies, etc. Only glass-bonded mica has lower moisture absorption.

For instance: the accuracy of water meters depends on strength, long-life, and stability of the hard rubber parts—expected to last 10—even 20—years under water. Here fatigue resistance is vital, as the parts may go through 50,000,000 or more cycles in a lifetime.

With many different Ace Hard Rubber molding compounds, sheets, rods and tubes to choose from—also other Ace plastics such as Ace-Tex, Parian, Saran—you can select just the right combination of technical properties. And with our complete molding, extruding and fabricating facilities (among the world's largest) at your service, your job will be done the best way, the quickest.

Always check your Ace Handbook, pgs. 4 and 5, when selecting molding materials. If you haven't a copy of this valuable 60-pg. manual, *write today—it's free.*

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HARD RUBBER and PLASTICS
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET • NEW YORK 13, N. Y.

of PRODUCT ENGINEERING, page 150, under the heading of Heat Resistant Paints developed in Australia.

—G. A. BIANCO
Thomson Laboratory

Ed.—Sorry, but that paint is not yet commercially available. For full details write the Council for Scientific and Industrial Research at 314 Albert Street, Melbourne, C.2, Australia.

Stamped Gears

To the Editor:

We are seeking a source of supply for stamped gears and would appreciate any information you may have as to possible suppliers.

More specifically we are interested in locating a source for an internal spur gear of the following approximate specifications: steel stamping, 4 in. Pitch Diameter, 24 Diametral Pitch, 20 deg. Pressure Angle (Preferable), 1/16 in. Face Width, 5 in. Outside Diameter and 3 or more dowel holes to permit stacking to 3/16 in. face width.

Any information you can forward will be much appreciated.

—G. H. CUNARD
Vonnegut Moulder Corporation

Ed.—On the face of it, this seems to be an easy stamping to manufacture. There are literally thousands of people who should be able to do the job. In addition to those who specialize in steel stamping, there are many people who make laminations for their own use. Some of these manufacturers might take on a small contract. We suggest that you try Mullins Manufacturing Co. of Salem, Ohio and Worcester Pressed Steel Company of 101 Barber Avenue, Worcester, Mass. Either of these two companies should be able to supply your needs.

Small Zinc Alloy Die Castings

To the Editor:

Will you please cite me a reference to the step-by-step castings, as described on page 132 of the new 9th series Design Work Sheets compiled by PRODUCT ENGINEERING.

—DR. W. T. BOVIE
Fairfield, Maine

Ed.—You might write to the author Mr. Joseph Saks, at the Gries Reproducer Corp. 780 E 133 St, New York or Mr. C. R. Maxon, Market Development Division, New Jersey Zinc Company, 160 Front St., New York, N. Y. Either of these two men should be able to give you the information that you require.

UNEQUALED FOR HIGH RATIO, HIGH SPEED DRIVES..

WHERE GEAR SIZES MUST BE KEPT TO A MINIMUM

HYPOID GEARS are the ideal combination for power transmission between shafts at *any angle and speed*. Actually, the unsurpassed performance of Hypoids result largely from the curvature and obliquity of teeth—assuring continuous pitch line contact and an overlapping action, which allows at least two pairs of teeth in contact at all times—smooth transfer of load from tooth to tooth (without noise and vibration) and increased load carrying capacity, due to the distribution of load over a greater number of teeth.

HYPOID GEARS are similar to spiral-bevels, but have pinion axis offset above or below center of gear axis. Gear and pinion shafts of a Hypoid pair can continue past each other . . . this direct and compact arrangement is used to advantage in steel mill, paper mill, and printing plant machinery, etc. Other advantages are: more room to place bearings on both sides of gear and pinion, and in some cases, lowered or raised position of the pinion, allowing arrangements of machinery which would otherwise be impossible.

Send for the "Gear Book," which contains 68 pages of highly useful information, in fact, it's almost a "treatise on gears." Please use your Business Letterhead when writing for this Catalog.

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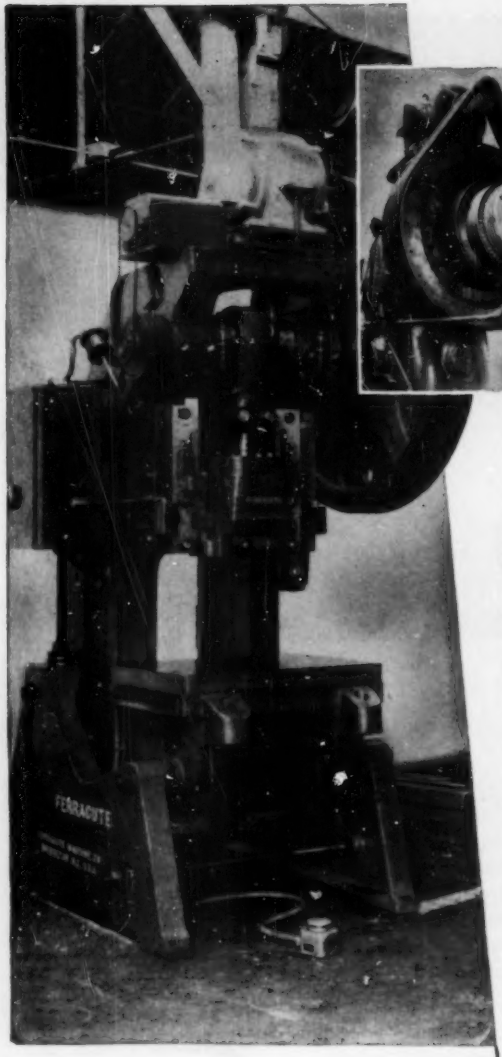

Ferracute 75-ton Punch Press equipped with Twin Disc Model P Air-actuated Clutch.

Close-up of Model P Clutch installed on Ferracute Punch Press.

100% Faster Punch

Obtained from Twin Disc Model P Air-actuated Clutch

The problem was how to increase the short-stroke speed on a punch press. The Ferracute Machine Co., Bridgeport, N. J., called in Twin Disc engineers . . . who recommended Twin Disc Air-actuated Clutches. The result . . . *100% faster punch*. Now their complete line of 40 to 110 ton presses uses Twin Disc Air-actuated Clutches.

Twin Disc Models P and PH Air-actuated Clutches—standard on many types of heavy industrial equipment—offer advantages in any application where remote control operation is desired. Less shaft space is needed, permitting closer shaft bearing center distances. They have ideal operating characteristics: high torque capacity . . . fast or slow engagements . . . the ability to absorb heat . . . automatic adjustment for longer wear-life.

Simple in design, rugged in construction, Twin Disc Model P and PH Air-actuated Clutches are built in a wide range of sizes (14 to 42 inches) and capacities (75 to 1325 hp), permitting the selection of exactly the right clutch for every installation. Write for Bulletin 139-B. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

3 record-making problems...

and how photography helps solve them

...with savings

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SOLUTION: Make photocopies with Kodagraph Contact Paper. Anyone, with simple equipment, can easily make accurate, lasting photocopies of documents and letters. Kodagraph Contact Paper is durable, uniform in quality. Developed specifically for use with existing contact photocopy machines, it has wide latitude . . . assures crisp copies of unsurpassed legibility.

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More legible photocopies at low cost with Kodagraph Contact Paper.

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SOLUTION: Make *photographic* duplicates in one printing on Kodagraph Autopositive Paper, and get file prints or intermediates that will stand the wear and tear of handling and machine feed-throughs . . . that won't yellow, smudge, or fade. Kodagraph Autopositive Paper can be handled in ordinary room light, and can be exposed on familiar direct-process or blueprint equipment.

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Longer lasting, higher quality intermediates on Kodagraph Autopositive Paper.

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SOLUTION: Put inactive records on microfilm, destroy the obsolete originals, and use the file space so obtained for newer records. Microfilming can reduce the bulk of files by as much as 98%—a sensational saving in space. Record your smaller papers, your larger documents and drawings with Kodagraph Micro-File Machines and Recordak microfilming equipment and service.

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Space savings—up to 98% —through Kodagraph and Recordak microfilming.

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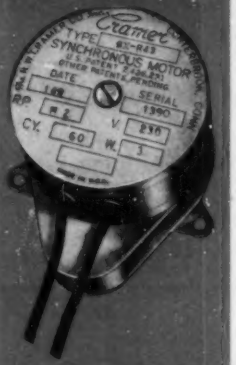

Cramer

TYPE SX

SYNCHRONOUS MOTORS

The Cramer Type SX Synchronous Motor is a superior power plant designed for applications requiring a constant speed at a given frequency. Widely used throughout the instrument and control fields, the Type SX is a highly efficient permanent magnet type motor . . . producing an exceptionally high torque of 30 in. oz. at 1 RPM, 60 cy.

Close tolerances of magnetic field construction and precision alignment of gear train, assure long, uninterrupted service at low cost. Self-starting, the Type SX reaches synchronous speed within ½ to 2 cycles . . . stops within one pole of motion on 240 RPM rotor shaft (1/60 sec.). Standard gear trains range in speeds from 60 RPM to 1/24 RPM . . . available for 25, 50 and 60 cycle operation.

For compactness, flexibility, accuracy and uniform timing performance . . . specify the Cramer Type SX Motor.

ADAPTATIONS OF TYPE SX MOTOR

CHART DRIVE TYPE

With heavy duty supplementary gear train. Sixteen output shaft speeds ranging from 2 RPM through 1 rev. in 10 days. Can be equipped with 2-way friction clutch or anti-backlash gearing.

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With differential clutch . . . designed for time delay relays or any type of timing mechanism requiring resetting operation. Wide variety of speeds.

REVERSIBLE TYPE

Shaft operates in either direction, permitting three combinations . . . 2 speeds forward, 1 reverse . . . 2 reverse, 1 forward. Wide range of speeds.

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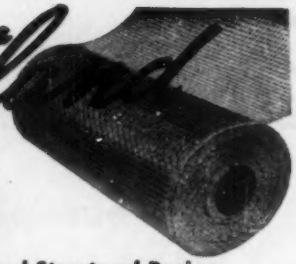
Box #7, Centerbrook, Conn.

Cortland BRAND



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For Mechanical and Structural Design

Whatever your design problem with wire cloth for mechanical or structural parts, call on Wickwire Brothers, Inc. — specialists in wire manufacturing since 1873 — for experienced information. Wickwire's CORTLAND Brand Industrial Wire Cloth is made to meet your specifications—

Sizes: One inch to 30 Mesh
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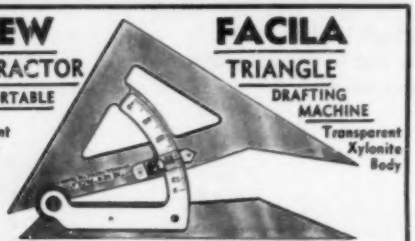

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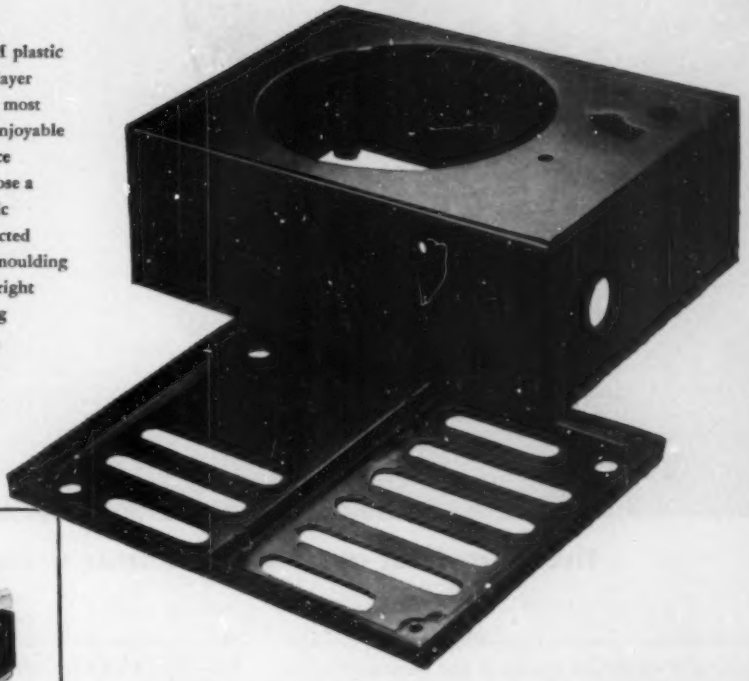
E. S. BROWN, IMPORTER

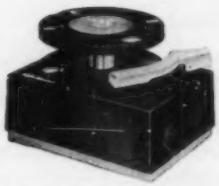
1122 Earl Ave. Schenectady, N. Y. U. S. A.

Here's one for the record—

(RCA Victor's New Vinyl Plastic Record)

Designed for the sensationally successful RCA Victor 45 RPM plastic records, this compact record player provides recorded music at its most convenient, inexpensive and enjoyable best. In combining performance with economy, RCA Victor chose a special maroon phenolic plastic for the cabinet and base—selected Kurz-Kasch for the exacting moulding job. This combination of the right plastic and the right moulding facilities produced the sturdy, attractive unit pictured here.





Record Player by RCA Victor
Cabinet and Base by Kurz-Kasch

Here's a shining example of cooperative planning in plastics. RCA Victor and Kurz-Kasch worked together to produce these carefully engineered mouldings on a quantity basis—with the results you see above. In *your* case, good results are just as certain. When you want a complete job—where long runs and delivery schedules are important—we're ready to handle it for you. We've got the staff, the equipment and the reputation necessary to solve your plastics moulding problems. Let one of our engineers tell you more about our facilities.

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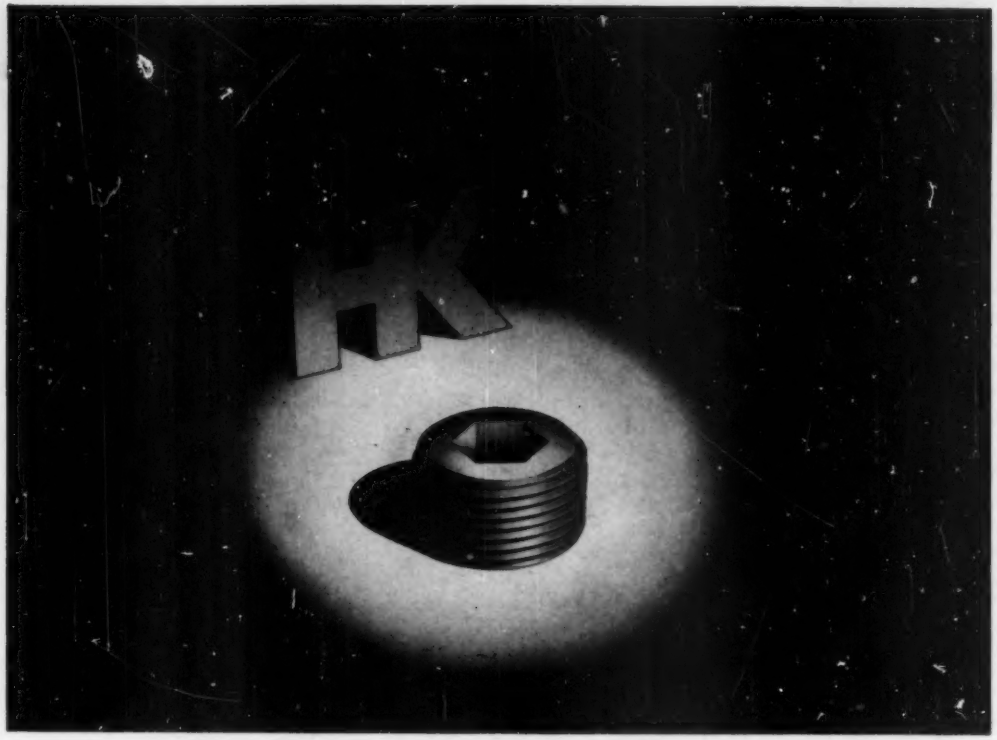

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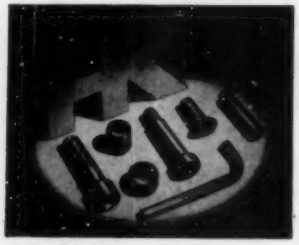

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NEW CATALOGS AND BULLETINS

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(1) **ELECTRICAL HEADERS AND LEADS** — Electrical Industries, Inc., 81 Hummer Ave., Newark 4, N. J. Data sheets, 12 pp. A group of data sheets and bulletins, bound in a folder, give full engineering information on hermetically sealed terminals and other small electrical parts.

(2) **STEEL CASTINGS**—Dodge Steel Co., Tacony, Phil. 35, Pa. Bulletin, 16 pp. Gives the chemical and physical properties of several carbon steels, carbon-molybdenum steel, chromium-molybdenum steel, and other common alloys. A short summary describes each alloy, giving its strong and weak points, possible uses.

(3) **VIBRATION CONTROL UNITS**—Pinn and Co., 2864 Eighth Ave., New York 30, N. Y. Bulletin, 80 pp. Gives short coverage of theory of vibration isolation and illustrates a number of vibration isolators, giving applications and engineering specifications of each. Also presents data on stainless steel flexible hose.

(4) **PIPE BENDING**—Wallace Supplies Mfg. Co., 1304 Diversey Pkwy., Chicago 14, Illinois. Booklet 43 pp. Gives the necessary technical information for bending pipe, tubes, conduit, bars, and other structural members. Also presents a great many types of bending machines, including shears and cutters, hand operated bending machines, fabricating tools and special machinery.

(5) **ABRASIVE SEGMENTS** — Simonds Abrasive Co., Phil., Pa. Bulletin ESA-156, 4 pp. Pictures and drawings show uses of abrasive segments for various surface grinding and machine knife grinding jobs. Recommendations are given for the various types of abrasive segments to be used with particular materials or jobs.

(6) **STAINLESS STEEL PUMPS**—Goulds Pumps Inc., Seneca Falls, N. Y. Bulletin 733-4, 4 pp. Designed for handling corrosive liquids in the process and other industries, these stainless steel centrifugal pumps are available in eight sizes with capacities up to 750 gpm and heads up to 180 ft. Full specifications including performance curves are given in the bulletin. Cutaway photos and drawings explain construction features.

(7) **GEARS**—Perkins Machine & Gear Co., West Springfield, Mass. Bulletin 4 pp. Pictures and text describe helical, bevel, spiral-bevel, worm, spiral, spur and ground thread worm gears. The company makes these gears of all usual sizes and types as a custom product for other manufacturers.

(8) **HOSE COUPLINGS**—Hose Accessories Company, Lehigh Ave. at 17th St., Phil. 32, Pa. Bulletin 5, 4 pp. Describes a complete line of suction and water hose couplings. Combination male hose nipples, brass and malleable suction and water hose coupling, hose pipe and adapters are included. Sizes and other pertinent information are given.

(9) **MEEHANITE CASTINGS**—Meehanite, Pershing Square Bldg., New Rochelle, N. Y. Bulletin 24, 8 pp. Using the question and answer technique, this bulletin points out the composition, qualities, uses and properties of Meehanite Castings. The bulletin points out the difference between Meehanite and cast iron and gives some of the points to be remembered when designing with Meehanite.

(10) **BALL BEARING**—Marlin-Rockwell Corp., Jamestown, N. Y. Bulletin 26, 40 pp. Called "M-R-C Ball Bearing Interchangeable Tables," the bulletin contains a list of bearing numbers of over 12,500 different ball bearings made by the various American ball bearing manufacturers.

(11) **VARIABLE SPEED TRANSMISSION**—Revco Inc., Dept. PE, 405 Thorpe Bldg., Minneapolis, Minnesota. Bulletin 149, 4 pages. Describes the "Zero-Max" variable speed transmission, which is a beltless, gearless, and non-hydraulic device having infinitely variable speed from zero to maximum. This low priced transmission is rated at 10 in.-lb. torque. The bulletin describes the unique operating principles and gives full specifications and price data.

(12) **COLD FINISHED STEEL BARS**—Monarch Steel Co., Inc., 141 - 161st St., Hammond, Indiana. Bulletin 25 pp. Gives the physical properties and uses of "Speed Case" and "Speed Treat" cold finished steel bars. "Speed Case" bars feature higher cutting speeds, longer tool life and improved finish. It is a low carbon, open hearth, case carburizing steel comparable to SAE 1112 steel. "Speed Treat" is a medium high carbon open hearth steel comparable to SAE 1045. Fast machining is an important feature of this steel.

(13) **ELECTRICAL HOUSE ORGAN**—Electric Specialty Co., Stamford, Conn. Periodical, Vol. 1, No. 1, 4 pp. New house organ is called "The Ecco Designer." It has a question and answer column, at least two technical articles each issue, and other features.

(14) **FASTENERS**—South Chester Corp., Finance Building, Phila. 2, Pa. Catalog 53 pp. Photos, drawings and tables show uses and operating principles of blind rivets, anchor nuts, springs, and special fasteners. The most interesting item is a blind rivet that is especially easy to expand. They require no special tool for use. These fasteners are in wide use in the transportation industry today and will find applications in other industries.

(15) **AIR AND HYDRAULIC CYLINDERS**—Hydro-Line Mfg. Co., 711-19th St., Rockford, Ill. Catalog 32 pp. Contains full engineering information on air and hydraulic cylinders for operating pressures to 2,500 psi. Beginning with the cutaway photo showing the general construction features of this whole line of cylinders, the catalog then describes foot mounted, flange mounted, clevis mounted and trunnion mounted cylinders with various styles of rods.

(16) **AIR-OPERATED CONTROLLERS**—The Bristol Co., Waterbury 20, Conn. Bulletin AI18, 32 pp. Photos and complete text material show construction and operating features of five types of automatic controllers for temperature, pressure, flow, liquid level, humidity, and pH value. The types include on-off, proportional, reset, derivative, and reset plus derivative.

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(17) FLEXIBLE SHAFTING — Elliott Mfg. Co., 36 Prospect Ave., Binghamton, N. Y. Bulletin 48, 4 pp. Describes a line of flexible shafting for power drives or remote control use. Types of shafting and sizes are recommended for various applications. A selection chart is also included. The company also offers a wide selection of control levers and knobs.

(18) ELECTRIC MOTORS — Allis-Chalmers Mfg. Co., 1003 S. 70th St., Milwaukee, Wis. Bulletin, 8 pp. Describes the "Safety Circle" motor, which is designed to prevent corrosion, distortion, undue friction and entrance of foreign matter. Cutaway drawings show all design features. Dimensions and specifications are also given.

(19) AXLE ASSEMBLIES—United Manufacturing Co., 31 W. Interstate St., Bedford, Ohio. Bulletin 101, 12 pp. Specifications are given for both two and four-wheel axle assemblies. The two-wheel assemblies have capacities up to 6,000 lb. and four-wheel units up to 12,000 lb. In addition many component parts and accessories, such as mounting brackets, hand brakes, spindles and hitching devices are listed.

(20) POWDER METALLURGY — F. J. Stokes Machine Co., Philadelphia, Pa. Booklet, 32 pp. The booklet gives a brief summary of the present status of powder metallurgy as a modern production method. It tells what the process is, gives applications, special applications, mechanical characteristics, design considerations, and a short historical background of the process. Drawings are used to give many case histories.

(21) ELECTRIC BRAKES AND CLUTCHES — Warner Electric Brake Mfg. Co., Beloit, Wis. Bulletin 701, 24 pp. Includes detailed drawings and photos of the "ICB" clutch and brake units for industrial machinery and electric motor applications. Also contains the formula for computing heat dissipation rates and a selection chart for Warner units.

(22) SPEED CONTROLLERS — Reeves Pulley Co., Columbus, Ind. Bulletin, 8 pp. Application photos show typical uses of the three basic types of Reeves speed control units. The text gives "before and after" data on machine tool production when the speed control units are used. The three basic units are: a Variable Speed Transmission, Vari-Speed Motor Pulley, and Vari-Speed Motodrive.

(23) INJECTION MOLDING—Tennessee Eastman Corp., Kingsport, Tenn. Booklet, 55 pp. Called "Tenite Injection Molding," this booklet is a procedural guide to the injection molding of Tenite I and II, which are cellulose acetate and cellulose acetate butyrate thermoplastics. It covers the choice of materials, product design, injection molding machines, mold design and construction, and various finishing operations.

(24) WIRE CLOTH — Ludlow-Saylor Wire Co., 634 S. Newstead Ave., St. Louis 10, Mo. Booklet, 32 pp. Photos and text show a line of wire cloth and screen made in many mesh sizes and types. This screen is made in wire sizes ranging from 1 in. bars down to the smallest wire sizes. The booklet shows the company facilities for manufacturing this screen.

(25) MOLDING HAND BOOK—Libbey-Owens-Ford Glass Co., Plaskon Div., 2112-24 Sylvan Ave., Toledo 6, Ohio. Booklet, 48 pp. The booklet gives the properties of molded Plaskon and the technique of molding. It also deals with proper mold construction, common molding difficulties and testing, defining and finishing plastic moldings. Many colored pictures show some of the uses of Plaskon. Tables and charts give the designer full engineering information.

(26) ELECTRONIC CONTROLS—Photoswitch, Inc., Cambridge, Mass. Booklet PG 4910, 44 pp. Forty-five case studies show how to cut production cost with electronic controls. Each case study has a line drawing to show the problem clearly and text material to give the solution and recommended equipment. An index lists the applications both alphabetically and by industries.

(27) WIRE ROPE SLING — John A. Roebling's Sons Co., Trenton, N. J. Bulletin, 8 pp. Pictures, drawings and tables describe slings available in rope diameters varying from ⅛ to 2 in. Full dimensions and breaking strengths are given.

(28) BALL BEARINGS—New Departure Div., General Motors Corp., Bristol, Conn. Bulletin 16 pp. Describes five distinct types of "self-sealed" and "lubricated-for-life" ball bearings designed for belt and trolley conveyors, foundry mold car wheels and similar applications.

(29) PUMP SEALS—Byron Jackson Co., Los Angeles 54, Calif. Bulletin 48—10,000, 12 pp. This illustrated bulletin describes the three types of Byron Jackson Mechanical Seals for centrifugal pumps. They are designed for sealing stuffingboxes in centrifugal pumps handling hot and cold liquids, either corrosive or non-corrosive.

(30) AIR GAGES—The Sheffield Corporation, Dayton 1, Ohio. Catalog DTF-491, 14 pp. Features the dial type Precisionaire and illustrates the various models available. This dial type air gage is used for dimensional checking and features a quick, dead-stop indicator action. The bulletin present many application photos.

(31) METAL LETTERS AND FIGURES—H. W. Knight and Son, Inc., Seneca Falls, N. Y. Catalog 28, 18 pp. Shows styles, sizes, and types of metal letters and figures. Among other applications, they can be used with castings or patterns to mark numbers or manufacturer's name.

(32) GAS PUMPS — Roots-Connersville Blower Corporation, Connersville, Ind. Bulletin 31-B-17, 8 pp. Covers type XA Gas Pumps, which are built in 18 standard sizes with capacities ranging from 8 to 624 cfm up to 2 lb., from 6 to 230 cfm up to 4 lb., and from 5 to 175 cfm up to 6 lb. Sectional views are included, along with a chart to graphically illustrate volume and power characteristics of constant pressure and variable-speed, multi-speed, or constant-speed drives.

(33) HIGH STRENGTH CERAMICS—Landes, Zachary & Peterson, 373 South Santa Fe Drive, Denver 9, Colorado. Bulletin 1040, 6 pp. Describes the newly-developed Coors High Strength Ceramics for mechanical and electrical uses. These materials are used as mechanical parts of equipment where corrosion, high temperatures, excessive friction, wear or galling limit the service life of metals.

(34) HYDRAULIC "O" RINGS — Crane Packing Co., Chicago 12, Ill. Bulletin 8 pp. Line drawings and tabulated information give all dimensions of hydraulic "O" rings. Recommendations are given as to the surface finish of cylinder or rod, materials for cylinder or rod surface, clearance between moving and stationary parts, groove dimensions, assembly and lubrication for pneumatic service.

(35) CASTINGS—The Wellman Bronze & Aluminum Co., 2525 E. 93 St., Cleveland 4, Ohio. Catalog 50, 16 pp. Describes the company' non-ferrous castings and wood and metal patterns. The company makes these patterns in both wood and metal for other manufacturers. They also produce their own non-ferrous castings. The catalog includes tabulated information.

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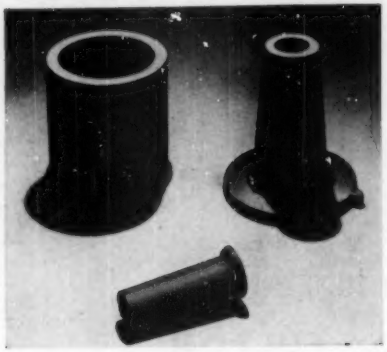

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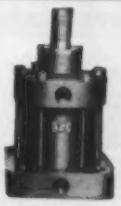

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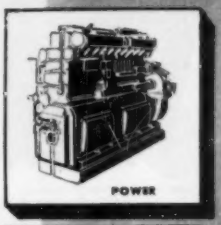

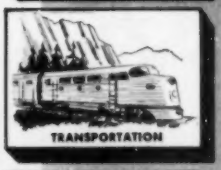

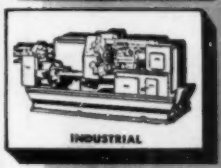

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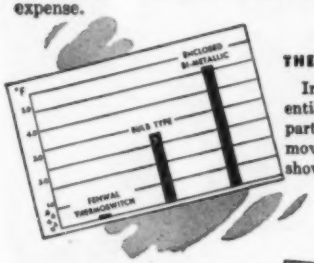

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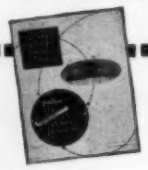

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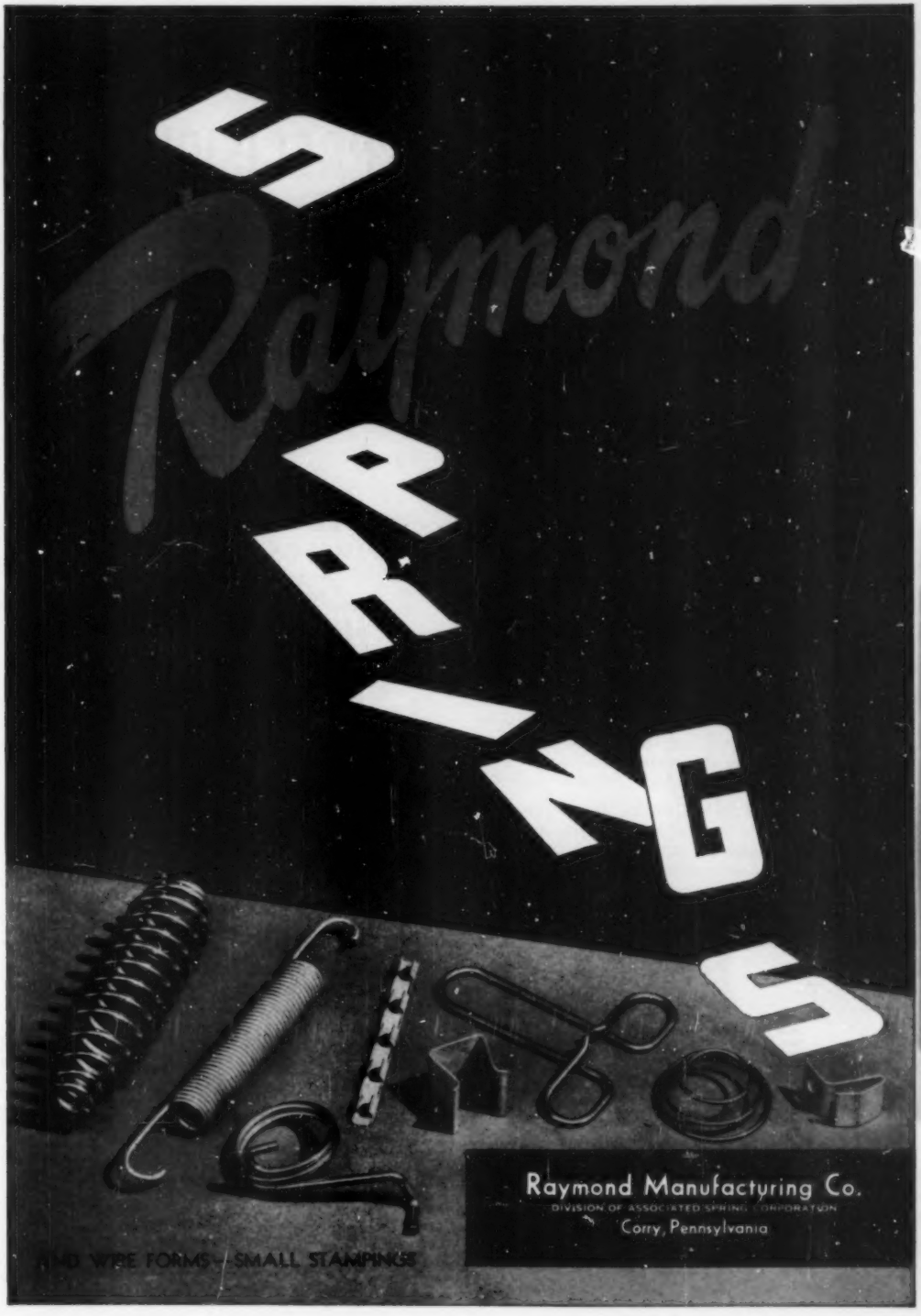
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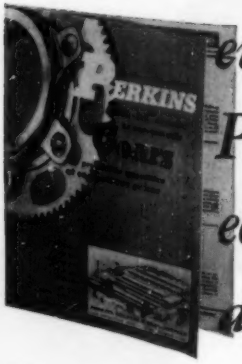

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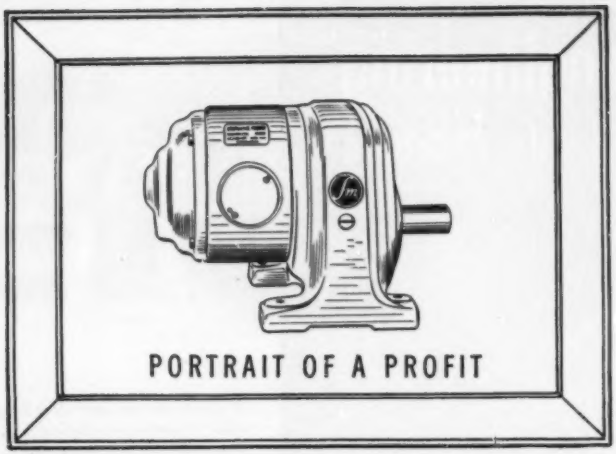

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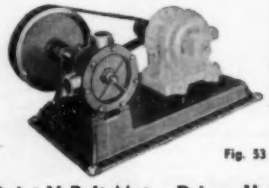

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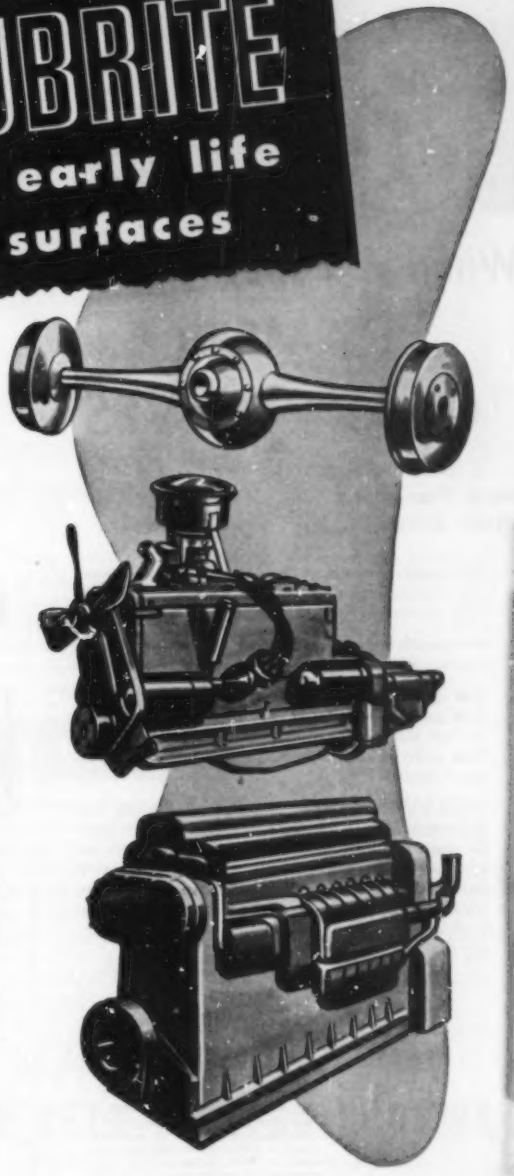

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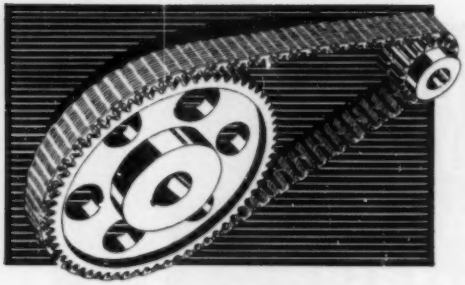

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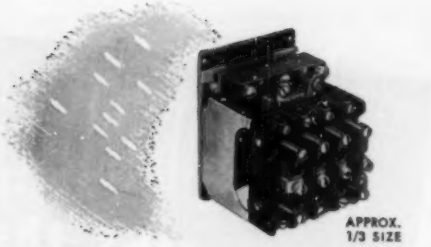

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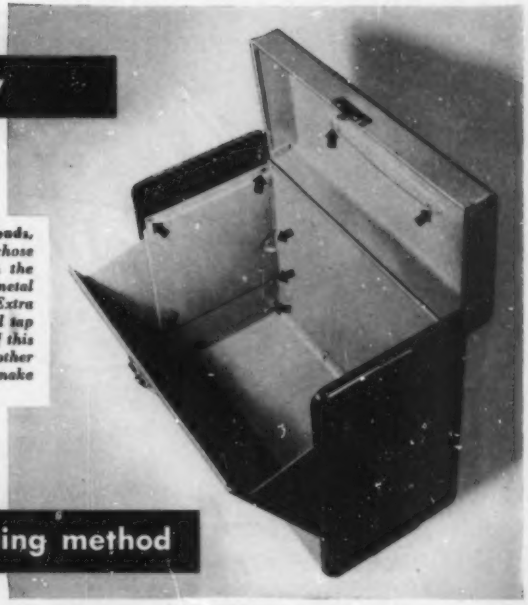

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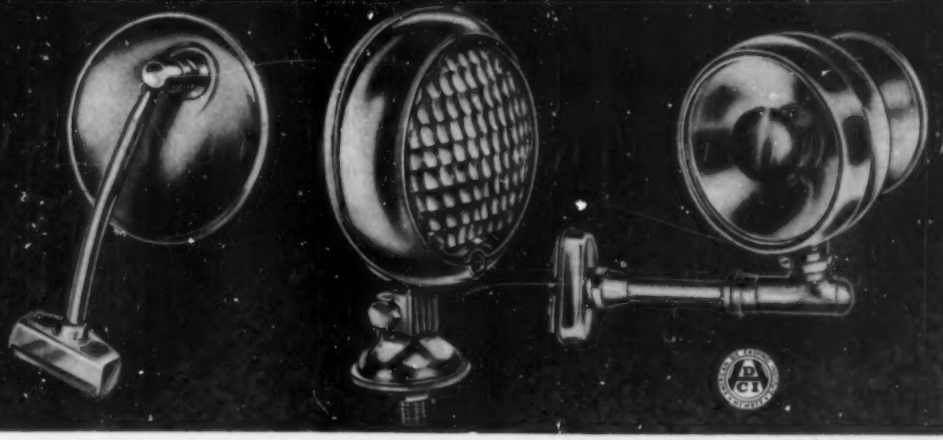

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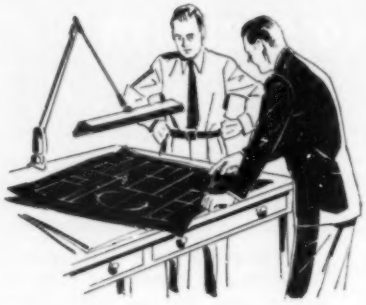

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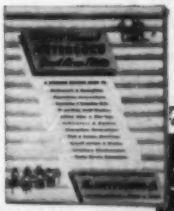

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- how to budget time most efficiently
- 12 tested techniques for giving instructions
- how to talk to groups effectively
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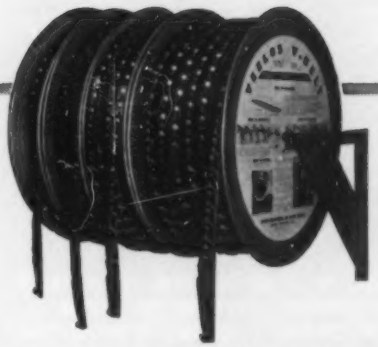
"Me . . . stock all those endless V-Belt sizes?"

"Not since I use VEELOS"



"I can replace any V-belt in our plant with just these reels of Veelos."

That's a typical Veelos user telling you how Veelos cuts V-belt inventory. If you use O, A, B and C widths, four reels of Veelos give you a choice of more than 316 sizes. Use only A and B? Then two reels are all you need.

Buying matched sets of endless V-belts is costly. Forget it with Veelos. Forget, too, belt deterioration and obsolescence. Veelos on reels saves storage space . . . simplifies stock records.

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THE LINK
V-BELT

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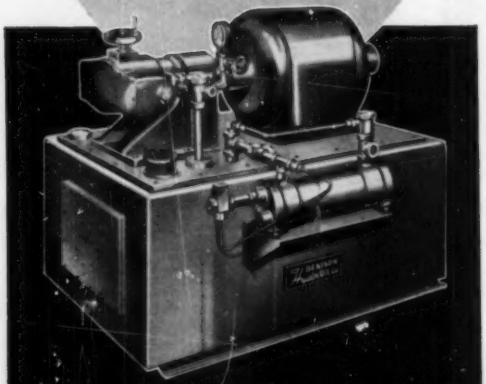
MANHEIM, PA.

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 300 distributors throughout the country. Veelos is known as VEELINK outside the United States.

NEW

DENISON *High Pressure* HydrOILic PUMPING UNIT



UP TO 5000 PSI . . . UP TO 35 GPM . . . CONSTANT OR VARIABLE VOLUME . . . OPTIONAL OIL COOLERS . . . CHOICE OF CONTROLS . . . DESIGNED TO SPECIFICATIONS OF JOINT INDUSTRY CONFERENCE, HYDRAULIC STANDARDS

Here's new, higher-level pumping efficiency—in 22 new models covering a wider range of hydraulic circuit needs.

These advanced HydrOILic Pumping Units offer maximum pressures to 5000 psi. Features include axial piston pumps in three sizes for either constant or variable volume operation, with volume capacities of 10, 20 and 35 gpm. Variable volume control is by handwheel, stem, or pressure compensation.

The rugged, welded steel reservoirs form the base of these new pumping units. Bottoms of all reservoirs are slightly raised and sloped, for easy cleaning and draining. All operating components, including electric motor, pump, relief valve, gauges and controls are mounted on a removable top.

For heavy-duty or continuous operation, a standard 2-pass heat exchanger with automatic thermostatic control is optional. A vacuum gauge for indicating suction condition of the reservoir oil filter is also optional.

Many other features make these highly compact, amazingly *quiet* pumping units outstanding for industrial needs of every type. Write for complete details.

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The DENISON Engineering Co.

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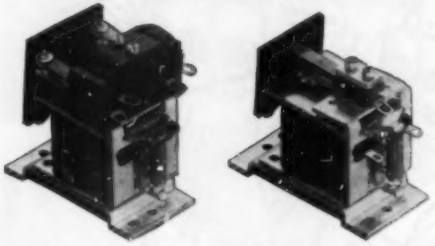

...take a look at *R-B-M General Purpose AC and DC Relays*

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PIONEERS IN PROTECTION M&W Co. 1874

. . . where industry goes with finishing problems

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MANUFACTURERS OF INDUSTRIAL FINISHES

What does this mean to every user of

STAINLESS STEEL?

This is not a page of hieroglyphics from an archeologist's handbook — but rather a few designs copied down by an architect upon witnessing the amazing things moulding manufacturers are doing with Sharon Stainless Steels.

These shapes and many, many others are being cold formed of Sharon Stainless for use as functional and decorative moulding and trim for store windows, tables, automobiles, household appliances and so forth.

When it comes to extreme-forming, easy-working Stainless — you just can't beat Sharon — pioneer and prime producer of quality Stainless Steels.

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

PRODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL DIVISION, DETROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNA.; CARPENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, W. VA.; JOANNE COAL COMPANY, RACHEL, W. VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoop—Electrical Steel Sheets—Hot Rolled Annealed and Deoxidized Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

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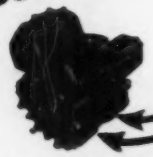
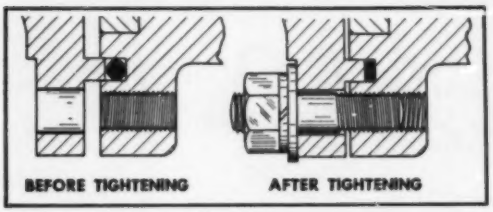
LINEAR "O" RINGS ON GUARD HERE...



Prevent Gasoline Leakage
Even at Temperatures of −55°C. to +70°C.



A primary consideration involved in the design of this Eclipse-Pioneer Autosyn* Fuel Flow transmitter was sealing the metering chamber to prevent gasoline leakage under *all* conditions. This transmitter had to operate satisfactorily over a temperature range of −55°C. to +70°C. This meant that a seal had to be selected that would not become brittle at extremely low temperatures and permit gasoline leakage.

Eclipse-Pioneer engineers state . . . "The simplified installation, low cost, and efficient sealing action of Linear "O" Rings have all been contributing factors to a practical solution of a very exacting problem."

In addition to being compounded of natural and synthetic rubber, Linear "O" Rings are also available in Kel-F or Silicone to resist actions of vigorous oxidizing materials over wide temperature ranges.

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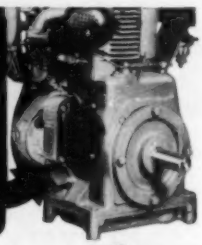
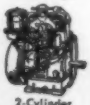
Why
WISCONSIN
Heavy-Duty *Air-Cooled*
ENGINES
have a Rotary Type
OUTSIDE MAGNETO



Wisconsin engineers have found through long experience and experimentation that the best place to put the magneto, not only for convenient accessibility but for better ignition performance over an extended period of time is on the OUTSIDE . . . with an independent, direct drive from the engine to the Magneto. The Rotary Type high tension magnetos used on Wisconsin Air-Cooled Engines provide the greatest protection against ignition troubles because the Magneto itself is a complete, independent operating unit that doesn't rely on an unrelated part of the engine for its successful operation. It's tightly sealed against dust and moisture, of course, so it isn't affected by wet weather or snow and there is no chance of it getting "fouled up". And it's equipped with an *Impulse Coupling* that provides a quick, hot spark for easy starting in any weather, in any climate — a feature that can't be incorporated in a flywheel-type magneto.

Yes, the MAGNETO is important . . . both as to *type* and *placing* on the engine. It's the *right kind* and in the *right place* on Wisconsin Heavy-Duty Air-Cooled Engines. Specify "Wisconsin" for your 3 to 30 hp. power needs.

Single Cylinder
3 to 9 hp.


2-Cylinder
7 to 13 hp.

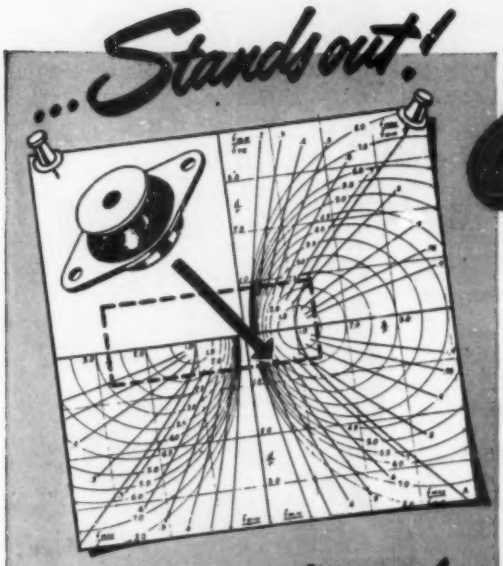
V-type 4-cylinder
15 to 30 hp.

MPHOURS
WISCONSIN MOTOR CORPORATION

Here's why

VIBRATION ISOLATION

with MB's ISOMODE* UNITS



FIRST OF ALL, Isomode units have equal spring rates in all directions—which means equal absorption of vibratory motions no matter what their direction. Thus, in suspending your product to damp major vertical vibrations, you're not apt to find lateral or angular motions still giving you trouble. This feature also makes designing easier, since you can install Isomode units at any angle!

WHERE you put isolators affects results too. How do *you* locate them—by trial, by involved calculations? There's a better way! Simply project your product on the Isomode Design Chart* and find *optimum* points almost by inspection! You'll find that with the right isolator at the right point, you can smooth many a serious "shake" into a negligible ripple.

(*Yours for the asking—write us)

FAILURE OF A MOUNT can void your most carefully designed suspension. But you needn't ever worry about the Isomode unit's durability. Notice the construction which allows the core to be balanced between compression and shear. Not only does this provide a stronger, more stable mounting, but also greater capacity to withstand shocks with smaller, lighter units.

THIS TYPE 5 ISOMODE unit is one of many MB mounts available to you. You can see why they are specified for the tough problems—and how they've managed to run up extraordinary service records on well-known products. If you have a vibration problem, let us show you how to eliminate it with an MB suspension.

*Trade Mark Reg. U.S. Pat. Off.

DO YOU HAVE OUR NEW BULLETIN ON FILE?

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THE MB MANUFACTURING COMPANY, Inc.

1060 State Street, New Haven 11, Conn.

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use Wolverine *Trufin for heat transfer

Worthwhile savings are effected in most installations. Unit costs are decreased because less tubing is required for each installation; consequently, the use of much other material is eliminated. Labor, too, is reduced. Note in the illustration how the fins are formed from the tube itself to give you a finned tube that will withstand vibration and extreme temperature changes.

use Wolverine Spun End Process for tubular parts

Plain tubing is often employed in the fabrication of tubular parts because it has been found so much more economical than other methods of forming. This is particularly true in cases where the ends are formed in special shapes—with or without openings. For this fabrication investigate the Wolverine Spun End Process.

*REG. U. S. PAT. OFFICE

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ont.

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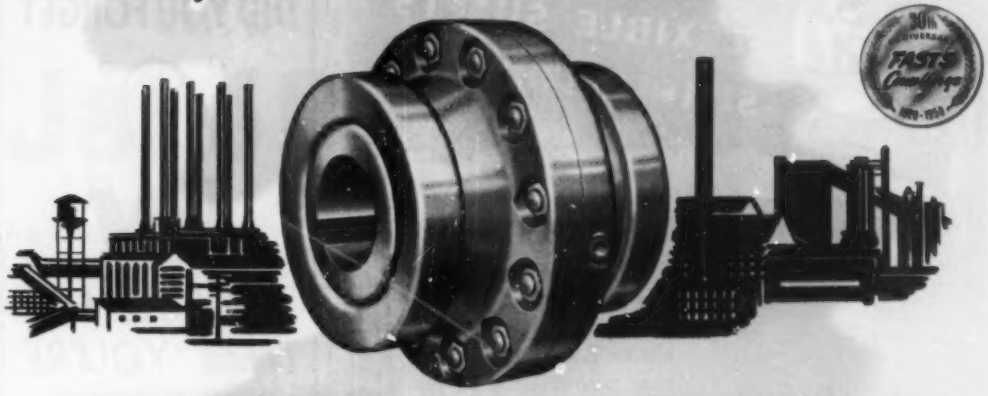

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By specifying Fast's, you get the benefit of Koppers Engineering Service, acknowledged best in the industry. Koppers Engineers, backed by 30 years coupling experience, study your problem . . . then show you *which* Fast's Coupling fits your application, (and more important) *why* you need it!

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GET THE FACTS: Mail coupon today for your free copy of the Fast's Coupling Catalog, published by Koppers. Shows how Fast's operate, describes the many sizes and types. Gives full details about Koppers Engineering Service. Send for your copy today.

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When power has to turn corners

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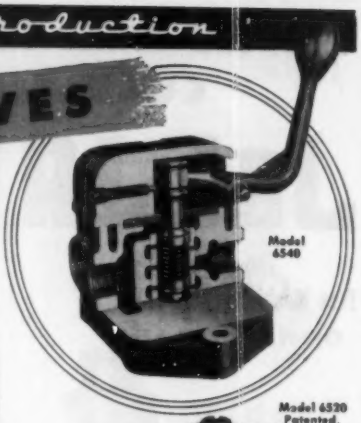

Model 6540

Model 6520 Patented. Dual-purpose valve.

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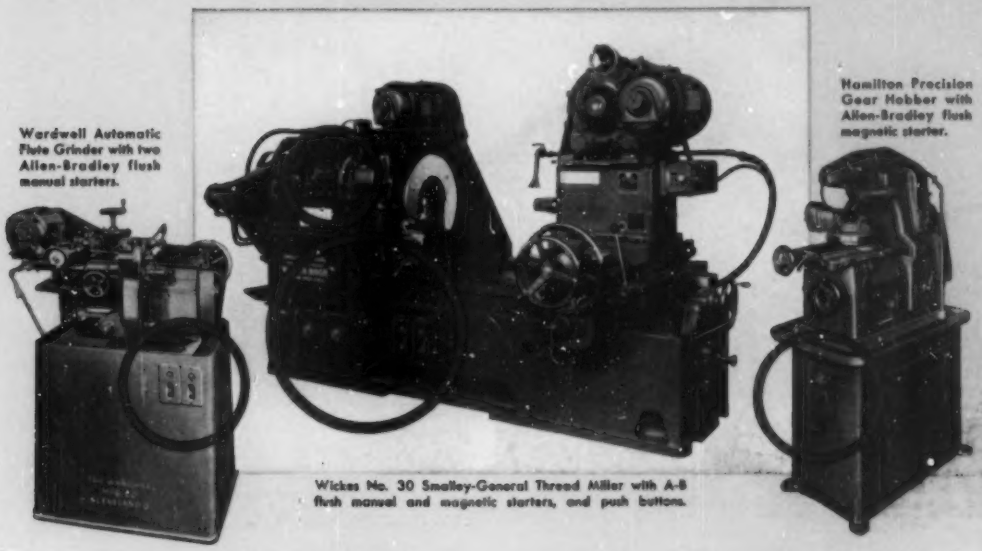


Wardwell Automatic Flute Grinder with two Allen-Bradley flush manual starters.

Hamilton Precision Gear Hobber with Allen-Bradley flush magnetic starter.

Wickes No. 30 Smalley-General Thread Miller with A-B flush manual and magnetic starters, and push buttons.

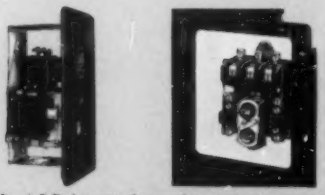
Modern styling calls for flush mounted starters that fit into machine bases. Above are a few examples of machine tools designed for "built-in" controls with flush covers.

Notice the smooth appearance of the machine bases. There are no control boxes to break the streamlined design . . . no exposed conduits to clutter the installation.

Allen-Bradley flush mounted starters are available for manual or automatic operation in various standard ratings and constructions. We shall be glad to send descriptive bulletins.

Allen-Bradley Company, 1316 S. Second St., Milwaukee 4, Wis.

BULLETIN 609 MANUAL STARTER



At left—A-B flush mounted manual starter in open type construction for enclosed recesses. At right—A-B manual starter in flush mounted cabinet for installation in open recesses.

BULLETIN 709 MAGNETIC STARTER

At left—A-B flush mounted automatic starter in open type construction for enclosed recesses. At right—Form 1 A-B unit installed in enclosed machine recess, with cover off.

A-B Quality

ALLEN-BRADLEY

QUALITY

TROUBLE FREE MOTOR STARTERS

with RELIABLE OVERLOAD PROTECTION

For Fractional Horsepower Motors

The National Electrical Code requires overload protection for all fractional horsepower motors started automatically or by remote control. The Bulletin 600 switch satisfies this need. Its dependable, accurate, thermal breaker trips the switch under a sustained overload, and protects the motor against burnout.

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GENEROUS WIRING SPACE—Though compact, this small switch provides plenty of wiring space. Its metal cover slips off, exposing front and two sides.

EASY TO INSTALL—No need to remove the starter from the enclosure during installation—saves at least 10 minutes of installation time.

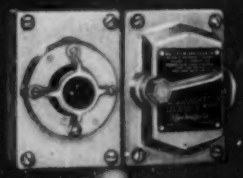
ATTRACTIVE APPEARANCE—This starting switch, with its clean, modern lines, is a sales asset to any motorized machine.

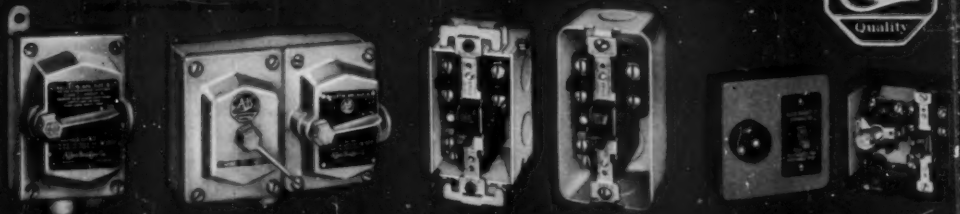
Allen-Bradley Company
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES FOR SMALL MOTORS

A-B Quality





JOHNSON

SLEEVE BEARING DATA

Bearing DESIGN

BRONZE

SLEEVE BEARING DATA

Standard Tests for Sleeve Bearings-2

As pointed out in the preceding data sheet—"Standard Tests-1"—the prime reason for the large number of tests employed is simply to assure the user that he is getting the greatest bearing performance possible for his money. This is necessary in Sleeve Bearings not only because there are so many types of bearings available but also because it is possible to so design any type to secure all the necessary properties. Cast bronze is a good example. There are approximately one hundred separate and distinct alloys from which to choose. If plasticity and/or embeddability is a chief requirement the usual method is to increase the lead content. If greater hardness is required, the lead content is lowered, then tin, or nickel, or manganese, for instance, is increased.

One of the chief points to remember in specifying sleeve bearings is that they can be "tailor-made" to suit practically any application. The only requirement is that we first determine all of the pertinent operating factors.

Johnson Bronze Alloy No.	PHYSICAL PROPERTIES			
	(1) Wear Rate (dry)	(2) Coefficient of Friction (dry)	(3) Izod Notch Toughness	(4) Resistance to Pounding
19	0.24	0.16	3.4	54
25	0.36	0.14	5.2	22
27	0.32	0.19	4.4	63
29	0.35	0.16	5.6	40
51	0.63	0.25	8.3	81
53	0.62	0.26	8.5	86
55	0.53	0.29	3.9	109
66	0.50	0.19	8.4	20
71	0.64	0.18	12.1	20
72	0.41	0.19	8.6	38

A typical listing and comparison of various popular, cast bronze bearing alloys.

Resistance to Fatigue

This is the ability of the bearing material to withstand shocks and loads without detericration or fracture. It is particularly valuable in testing bearings for internal combustion engines with rapidly alternating stresses on bimetal bearings such as steel backed, babbitt or bronze lined.

Izod Notch Toughness

This determines the amount of energy in foot pounds required to break a specimen. The specimen is notched and the energy required to fracture in a single blow indicates the toughness.

Resistance to Wear

This test determines the physical ability to resist destruction of two surfaces rubbing together without lubrication. The results are usually tabulated in the loss of weight in grams per 10,000 revolutions.

Resistance to Pounding

This is determined by establishing the number of blows of a hammer weighing 7.5 pounds, falling 2 inches, are required to deform the specimen 5%.

Coefficient of Friction

This test in bearing material is always computed on a "dry" basis, or a set up in which no lubricant of any kind is used. It is usually determined on an Amsler wear test machine.

Thermal-Conductivity

Thermal-conductivity is the ability of a bearing or bearing material to dissipate heat. It is a determination of the B.T.U.'s, per unit of time that will move through the material.

•

Engineering Service

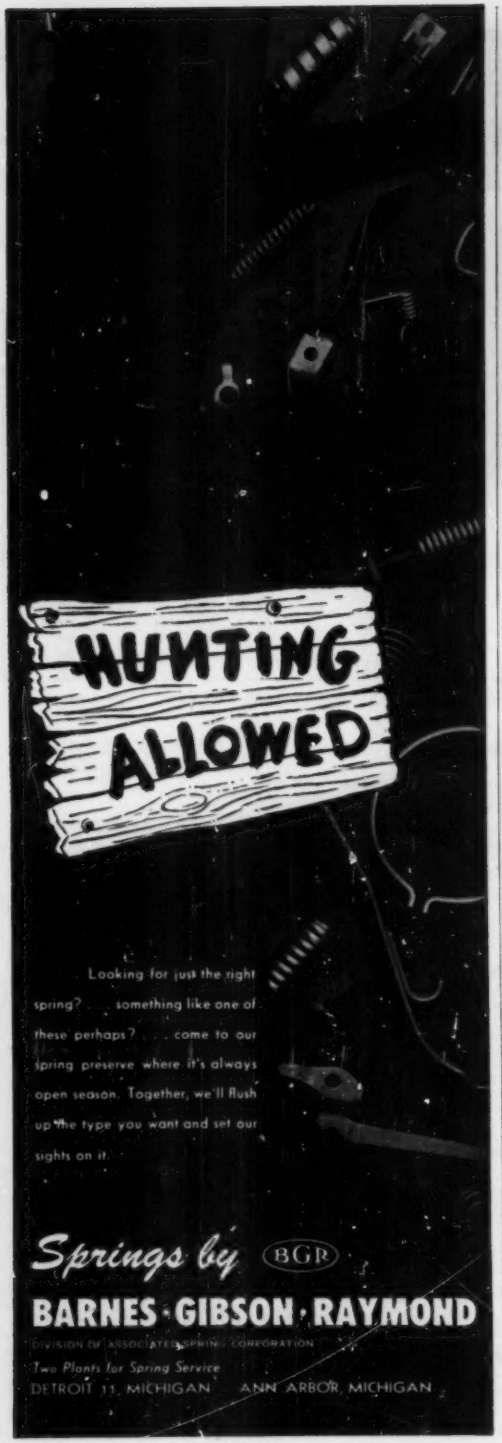
Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

•

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.



Looking for just the right spring? . . . something like one of these perhaps? . . . come to our spring preserve where it's always open season. Together, we'll flush up the type you want and set our sights on it.

Springs by BGR

BARNES · GIBSON · RAYMOND

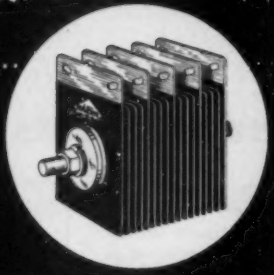
DIVISION OF ASSOCIATED SPRING CORPORATION

Two Plants for Spring Service

DETROIT 11, MICHIGAN ANN ARBOR, MICHIGAN

A Better Source of D.C. Power

with . . .



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"LEKTRON" RECTIFIERS

FOR:

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LAB. POWER SUPPLIES

FAST CHARGERS

ELECTRO-PLATING

AUTOMOTIVE AC GENERATORS

The only rectifier with Magnesium Radiator Plates, "Lektron" is lighter in weight—handles up to 60 Volts D.C. from 50 to 50,000 Amperes. They're more rugged mechanically, operate at temperatures from —40° F to 284° F and are not affected by normal atmospheric conditions. Complete engineering service available.

Write for literature.

Lektron

ELECTRONIC RECTIFIERS, INC.
2102 Spann Ave., Indianapolis 3, Indiana

To help you
design basic parts for quantity production
more economically and quickly

THIS practical book covers the design of basic parts for quantity production by die casting, sand casting, screw machine, stamping, die forging, hot and cold heading and plastic molding. Along with full explanations of the various high-production processes, you get many specific rules, amply illustrated to show their practical applications for designing products that lend themselves to rapid and economical mass production.

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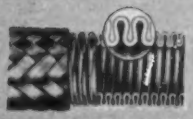
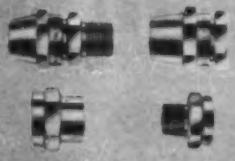
CMH

One dependable source for every flexible metal hose requirement



Corrugated Metal Hose in steel, bronze and stainless steel.

Convoluted Metal Hose in variety of types—steel, bronze and alloys.

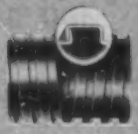


Couplings to meet every need.

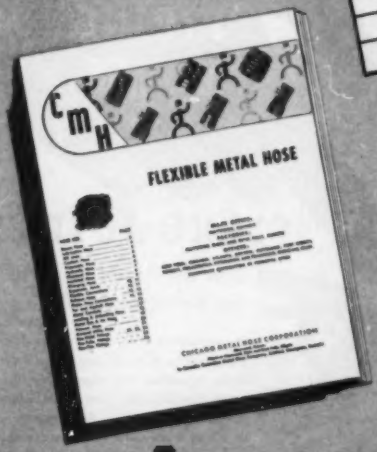
CMH	HOSE USE
√	Steam Hose
√	Lubrication Hose
√	Oil Lines
√	Coolant Hose
√	Pneumatic Hose
√	Hydraulic Hose
√	Chemical Hose
√	Insulated Hose
√	Charging Hose
√	Expansion Joints
√	Flexible Connections
√	Exhaust Hose
√	Platen Press Connections
√	Tar and Asphalt Hose
√	Metal Conduits
√	Loading & Unloading Hose
√	Gas & Air Hose
√	Vacuum Hose
√	General Utility Hose
√	Bellows
√	Flexible Lamp Arms

Expansion Joints for high and low pressures—stainless steel and copper.

Bellows in all sizes for all requirements—stainless steel and brass.



Metal Conduits in a variety of types and materials.



Now you can secure all your flexible metal hose needs from a single manufacturer. The handy check list above indicates only the more common types and assemblies manufactured by CMH. Other types and assemblies are also available. Bulletin 102, illustrated at the left, an application guide for CMH Flexible Metal Hose is available on request. Other literature giving full details on expansion joints, bellows and speciality items is also available. Write for your copies of the material in which you are interested and have it available for reference at all times.

Pioneer Identifies CMH products which have served industry for more than 47 years.

CHICAGO METAL HOSE CORPORATION

Maywood, Illinois

Plants at Maywood, Elgin and Rock Falls, Illinois
In Canada: Canadian Metal Hose Company, Ltd., Brampton, Ontario

Unsurpassed MACHINEABILITY

of FRONTIER 40-E ALUMINUM ALLOY

will produce better parts and products for you!

COMBINING lightness and strength with an unusual degree of machineability, FRONTIER 40-E is the ideal aluminum alloy for production of lightweight but durable products and parts.

Natural aging — rather than heat treatment — helps to heighten the machineability and other physical properties of Frontier 40-E Aluminum Alloy. Lapping and close-tolerance machine operations are possible, and castings made from 40-E can also be readily reamed or tapped. Absence of "tearing" by cutting tools produces a smooth finished surface. Machine speeds on sand castings have been increased as much as 20%, when FRONTIER 40-E ALUMINUM ALLOY is used.

FRONTIER 40-E ALLOY Offers You These 7 OUTSTANDING ADVANTAGES

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2. Corrosion Resistance is excellent, not only in standard corrosion tests, but also under stress.
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4. Readily Welded, without loss of physical properties. Does not require heat treatment after welding.
5. Machineability — far superior to the usual sand cast aluminum alloy. Machined parts have high lustre.
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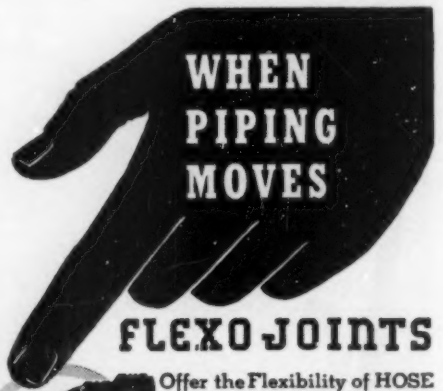
To get your FREE copy of the FEL-PRO GUIDE TO BETTER SEALING without obligation, just write your name and title on your company letterhead and mail to: Felt Products Mfg. Co., 1534 Carroll Avenue, Chicago 7, Illinois.

LOOK TO **FEL-PRO** for the LATEST in sealing materials



FLEXO JOINTS

Offer the Flexibility of HOSE the Strength of PIPE

For conveying pressures through moving pipe lines or to machinery or equipment while in motion, use dependable Flexo Joints. Complete 360° movement in either direction for pressures from gravity up . . . long wear—low maintenance cost. Four styles—standard pipe sizes ⅛" to 3".

Write for complete information

FLEXO SUPPLY CO., Inc.

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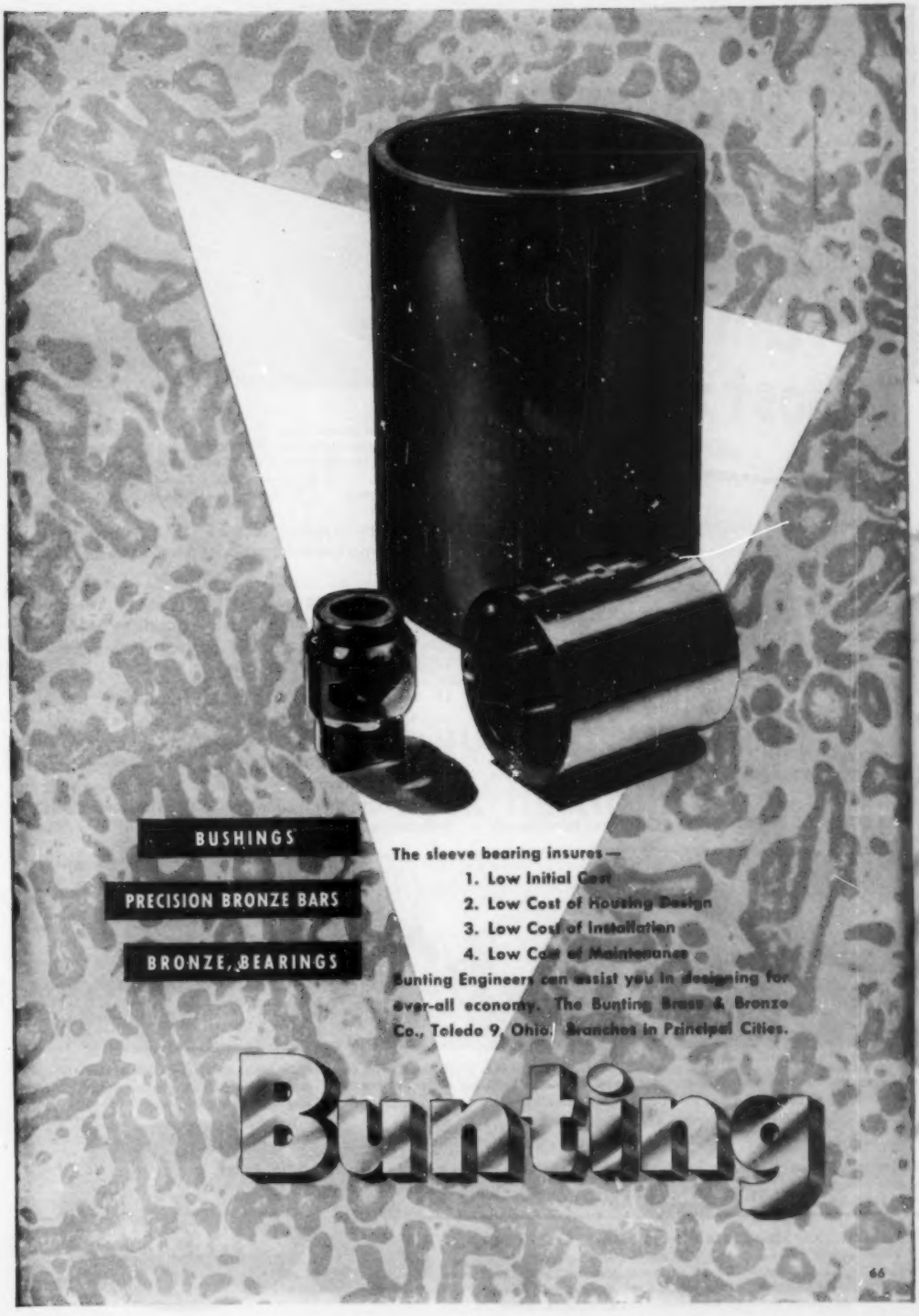
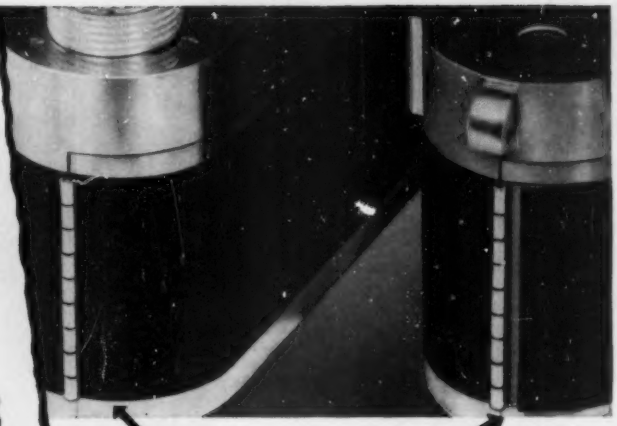

BUSHINGS
PRECISION BRONZE BARS
BRONZE BEARINGS
The sleeve bearing insures—
1. Low Initial Cost
2. Low Cost of Housing Design
3. Low Cost of Installation
4. Low Cost of Maintenance
Bunting Engineers can assist you in designing for over-all economy. The Bunting Brass & Bronze Co., Toledo 9, Ohio. Branches in Principal Cities.
Bunting

HOW TAILORED ADHESIVES can save lost sales



The covering on this camera is as firmly bonded to the metal case as the day it was made. Since the 3M Adhesive has been in use, not a single failure has been reported.

See how "guesswork adhesive" has shrunk simulated leather case covering and caused it to pull away from metal case. This often happened within a few days after manufacture.

TO IMPROVE HIS PRODUCT a midwest camera manufacturer switched from a leather case covering to Vinylite. But he found that the plastic was shrinking and pulling away from the metal case after a few weeks. His dealers were losing sales . . . too many cameras were being returned as unsatisfactory. And, naturally, factory sales were falling off.

A 3M ADHESIVES ENGINEER was called in and he found that the adhesive being used to hold the covers to the cases was causing the shrinkage. The bonding material which had worked so successfully on leather just wouldn't do the job on the new Vinylite covers.

AS SOON AS 3M ADHESIVE EC-847 was substituted, case covers stayed put, dealers and customers were satisfied and sales started a climb that's still continuing.

THIS PARTICULAR 3M ADHESIVE is one of the more than 1000 adhesives and coatings made by 3M. It's specifically engineered for perfect vinyl-to-metal bonding.

IF YOU'RE USING STAPLES, rivets, nails, tacks, screws for fastening, there's no question that you can save money and time and probably improve your product by using adhesives. If you're already using some type of adhesive, let us help you make sure it's the right one for the job. Ask us to send a 3M Adhesives Engineer.

First step in case covering operation is coating of die-cut simulated leather pieces with 3M Adhesive.

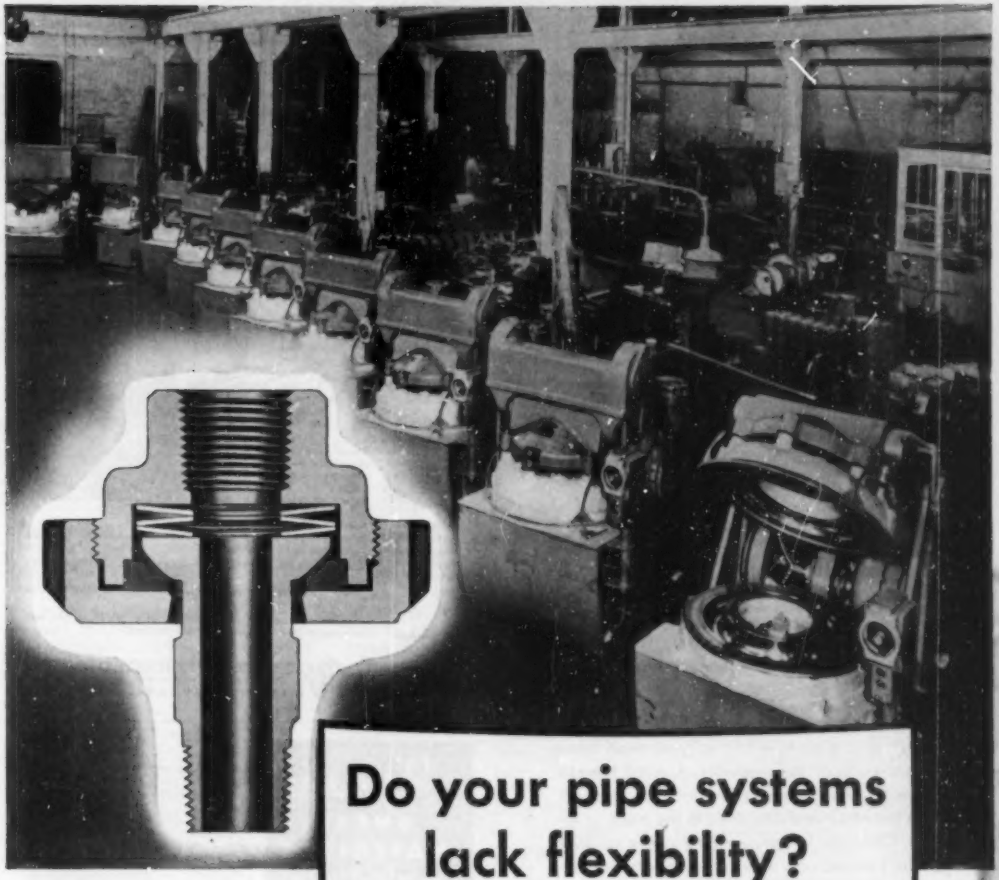
Metal housing is then brush-coated with the same 3M Adhesive EC-847 while coated covers cure under infra-red light.

Cover pieces are applied to metal case without pressure. 3M Adhesive assures complete overall permanent bond.

ANOTHER 3M COMPANY PRODUCT

3M ADHESIVES

Made in U. S. A. by **MINNESOTA MINING & MFG. CO.** St. Paul 6, Minn.
Adhesives and Coatings Division, 411 Piquette Avenue, Detroit 2, Michigan
General Offices: St. Paul 6, Minnesota
General Export: DUREX ABRASIVES CORP., *New Rochelle, N. Y.*
In Canada: CANADIAN DUREX ABRASIVES LTD., *Brantford, Ontario*



Do your pipe systems lack flexibility?

Here's an example of how

BARCO CAN PROVIDE IT

Every tire press in this assembly line is equipped with Barco Swivel Joints which provide the piping flexibility required to open and close the press.

For over 30 years Barco Joints have been serving industry and transportation—each year becoming more and more popular. Today, they are used in almost every kind of job requiring *flexible* fluid-conveying systems. By absorbing strain and stress, by compensating for expansion and contraction, Barco Joints have long been practically indispensable. Write for full information to Barco Manufacturing Company, 1800 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.

BARCO FLEXIBLE JOINTS

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

"MOVE IN EVERY DIRECTION"

No. 35—Product of
Jas. P. Marsh Corp., Skokie, Illinois

Chace Thermostatic Bimetal tells the "inside story" at a glance, in this easy-to-read home indoor-outdoor thermometer. A small bimetal coil is fixed at one end to the indicator shaft, with the other end attached to the back of the dial. Changes in temperature cause rotation of the bimetal coil, moving the indoor indicating pointer to the correct temperature value.

Chace #6650 Thermostatic Bimetal is specified, being particularly suitable for temperature indicators from −100° F. to +500°F., due to its extremely high deflection rate.

Manufacturers in many fields are taking advantage of the wide range of properties found in the complete line of Chace Thermostatic Bimetals. They've gained new freedom of design and improved product performance in such varied industries as automotive, appliances, instruments and industrial equipment. As the actuating element for *your* product in the field of temperature indication or control . . . specify Chace Thermostatic Bimetal.

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

PROBLEM: Drive a conveyor-belt carrying fragile material so that belt speed drops when drag of load increases.

SOLUTION: A Gast Air Motor maintains constant tension on material in process despite varying drag of load and belt r.p.m.

RESULT: This variable-speed drive reduces material spoilage—saves money.

UNUSUAL CONVEYOR-BELT PROBLEM solved with a variable-speed GAST AIR MOTOR

This case study illustrates two unmatched advantages of Gast Rotary Air Motors on original equipment applications. More advantages:

AIR MOTORS CAN'T BURN OUT—It's possible to stall them—but they can't burn out!

CAN'T SPARK EXPLOSIONS—No sparks—Gast Motors are explosion-proof.

GIVE VARIABLE R.P.M.—Controlled speed from 100 to 2,000—some to 6,000 r.p.m.

In many other ways, Gast Air Motors offer more—at less cost. Investigate now. "Air may be your Answer!"

WRITE TODAY! Request your copy of GAST'S IDEA-CATALOG

GAST ROTARY — AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO ONE H.P.) (TO 20 CFM.) (TO 25 INCHES)
GAST MANUFACTURING CORP., 139 Hobley St., Benton Harbor, Mich.

Unlimited Choice of Patterns
•
Accurate Holes Smooth Surfaces
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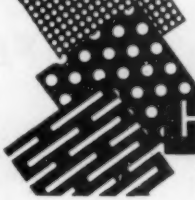
Design Facilities for New Applications

HERE AT H & K, you'll find an intelligent consideration of your industrial problems. Maximum cooperation is afforded designers and product engineers in the creation of Perforated Metals and other materials . . . providing the desired end results at lowest possible cost.

H & K Perforated means an extremely wide choice of sheet materials (coil and plate form, too) at your command. Stainless Steel is a perforating specialty at H & K. Monel, Brass, Bronze and Aluminum are others. Non-Metals include various Plastics, Cellophane, Foil, Masonite and a host of others. Write at once for full information.

Also Remember—H & K Grilles . . . Ultimate in Beauty . . . Utility . . . LONG LIFE!



The Harrington & King Perforating Co.
5630 FILLMORE ST., CHICAGO 44, ILLINOIS
114 LIBERTY STREET NEW YORK 6, N. Y.

Announcing Two ARMA INDUCTION POTENTIOMETERS

TYPE 1A400

. . . Time Saving, Cost Saving Components in Arma's Post-War Technique of electrical "Brain Block" instrumentation

"Brain Block" instrumentation quickly describes any custom arrangement of light, small, accurate standard Arma components to make precision instruments and controls.

For instrumenting problems of addition, subtraction, multiplication and division.

These two Arma induction potentiometers are high precision 400 cycle signal transformers having transformation ratios (of secondary voltage to primary voltage) which may be varied continuously between fixed minus and plus values by mechanical rotation of a projecting shaft. The transformation ratios are exact linear functions of the angular displacement of the shaft, within the inherent accuracy tolerances, from −45° to +45°. The shaft rotation may be continuous and also it may be in either direction.

TYPICAL CHARACTERISTICS

	Type 1A400 (Dwg. 715689-1)	Type 1B400 (Dwg. 715690-1)
Input Voltage Range	2 to 20	2 to 20
Frequency	400 ± 5%	400 ± 5%
Temperature	0° to 55° C.	25° C.
Transformation Ratio at 45° position	0.5000 ± 0.0005	1.0000 ± 0.0010
Phase (Output to Input)	0° 00′ ± 8′	3° 00′ ± 8′ Leading
Booster Amplifier Req.	#709825	none
Harmonic Voltages (Max. % of Input Voltage)	0.1%	0.2%
Weight	2 lb.	2 lb.
Moment of Inertia	1.2 oz. in.²	1.2 oz. in.²
Output Voltage		
1. Quadrature Component	Less than 0.25% of output voltage at 45° position.	
2. Inphase Component	See Note 1	See Note 2

Note 1. Type 1A400. The inphase component is a function of rotation between −45° and +45° and of input voltage in the range of 2 to 20 volts. In the temperature range 0° to 55° C. the inphase component of output voltage may be closely predicted from the following equation:

$$E_1 = kE\,\frac{A}{45°} \pm 0.1\%\,kE$$

where E_1 = Inphase output voltage
E = Input voltage
k = 0.5000 ± .0005 (the nominal ratio of output voltage to input at +45° position)
A = Mechanical angle through which the shaft has been turned from electrical zero, in degrees clockwise.

Note 2: Type 1B400. The above applies to type 1B400 except temperature must be 25° C. and k = 1.0000 ± .0010.

Features of Induction Potentiometers

- Can be used in computing with the introduction of minimum gear error, backlash and spring since all functions except the angle are handled electrically.
- Can eliminate physical proximity as a requirement of motions representing the quantities entering the computation (except for shaft angle).

Advantages of Arma Units

- All circuits isolated—no common leads.
- High mechanical accuracy—shaft diameter, shaft runout, flange runout held to exceptionally close tolerances.
- Small friction torque—about 3 milliwatts required to drive it from 0 to full output in 1 second.
- Self contained terminal blocks.
- Exceptionally well insulated.
- Convenient clamping on shaft.
- Workmanship of highest quality.

Specific Advantages over Wire-wound Types

- Stepless operation—outputs are smooth and uninterrupted by "wire-stepping".
- Unlimited rotation with no circuit interruptions.
- Many times longer life.
- Permanent accuracy—accuracy will not change as a result of use.

New Opportunities in Other Arma Components too

While you re-examine, in the light of these Induction Potentiometers, designs once limited by available components, you are invited to request whatever information you may need to explore the possibilities of using any Arma product which has been released from security restrictions.

ARMA CORPORATION

254 36th STREET, BROOKLYN 32, N. Y.

SUBSIDIARY OF AMERICAN BOSCH CORPORATION

ARMA PRODUCTS RELEASED FOR PRIVATE INDUSTRY

ARMA ELECTRICAL RESOLVERS* • ARMA SYNCHROS • ARMA INDUCTION MOTORS • ARMA INDUCTION GENERATORS • ARMA MECHANICAL DIFFERENTIALS • ARMA ALTERNATING VOLTAGE COMPARATOR • COMPUTING MECHANISMS • INDUSTRIAL CONTROLS • STABILIZATION DEVICES • NAVIGATIONAL EQUIPMENT • LINATRON AUTOMATIC INSPECTION SYSTEM

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QUALITY ARMA INSTRUMENT PRECISION

Tough yet Gentle

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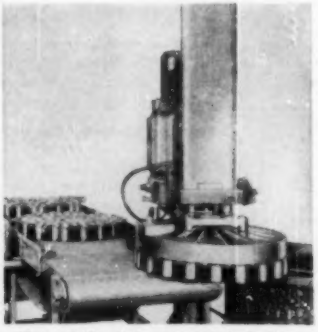

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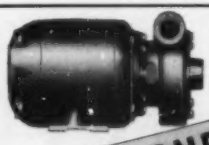

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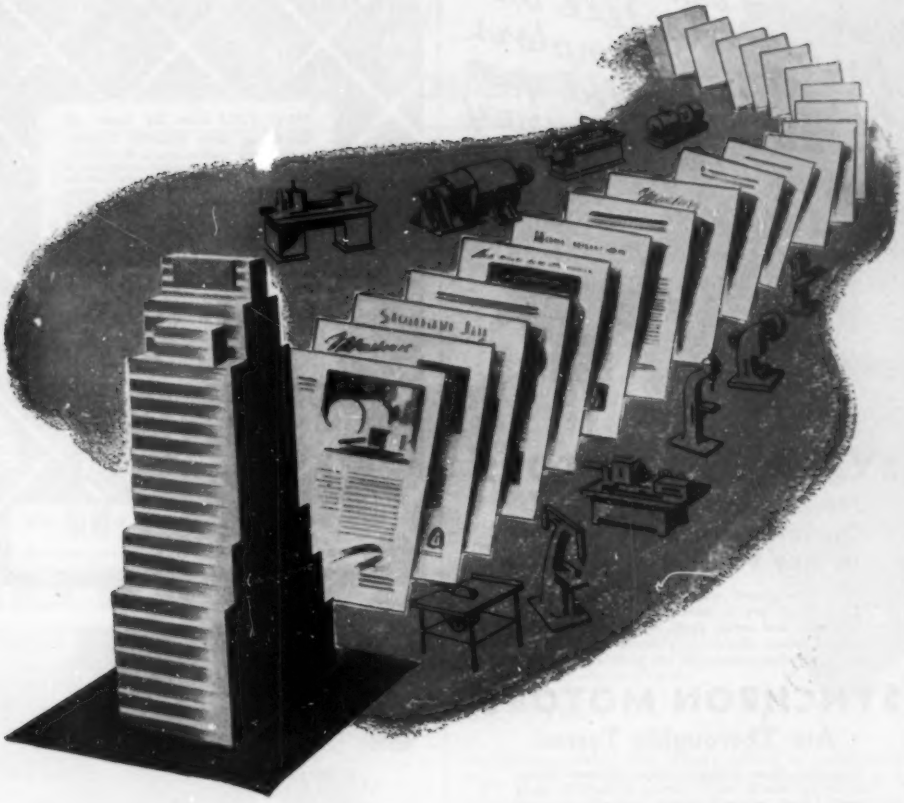

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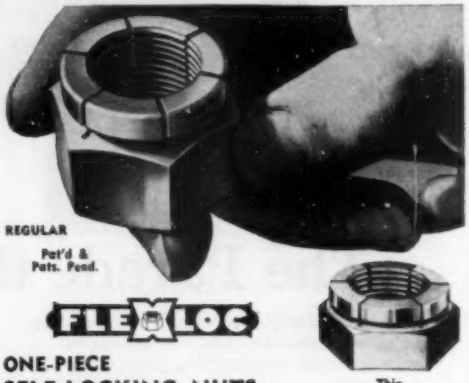

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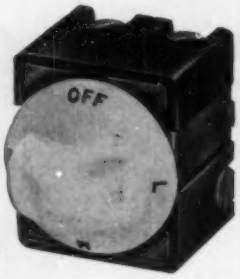

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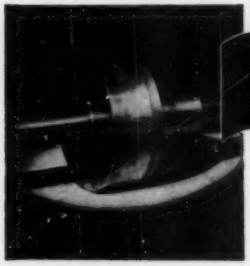

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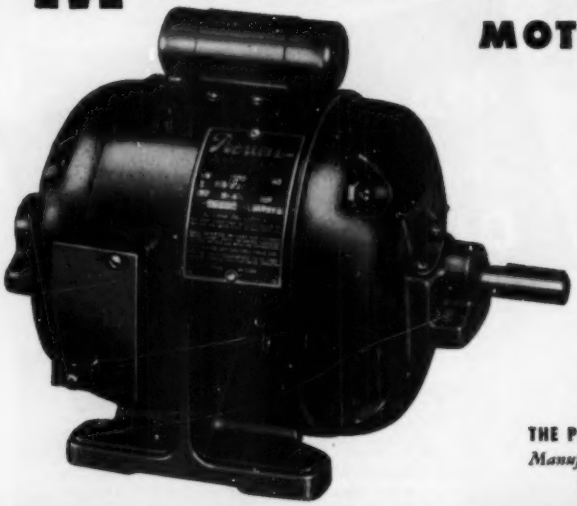

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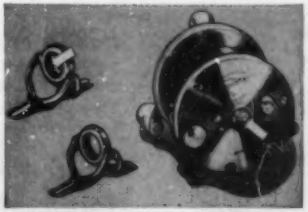
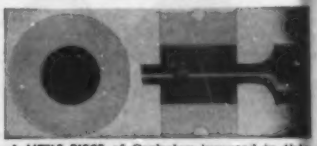


A LITTLE PIECE of Carboloy used here as a bearing gives fishermen a better, smoother-acting, longer-lived reel. And a little, wear-resistant Carboloy ring in these fish rod guides makes them last longer and operate more smoothly, by combating wear.



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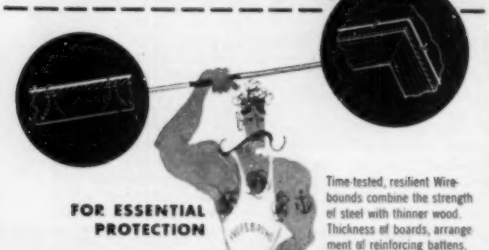
Wirebound Boxes and Crates come to you as flat mat units, ⅔ assembled. Most sizes are ready to pack in less than a minute. Wrap-around crate illustrated is typical of Wirebound time and labor saving designs. See below*



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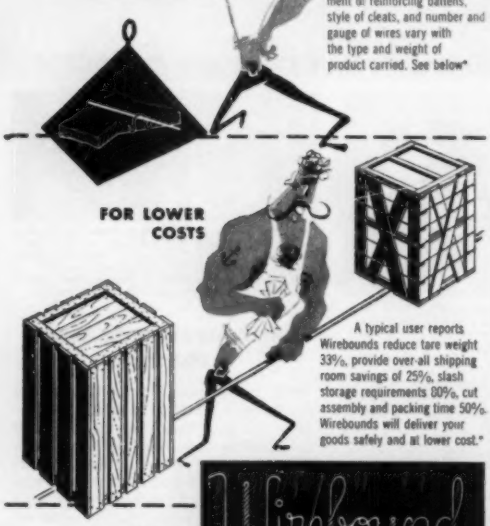

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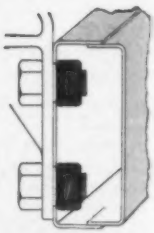

In "blind spots" like the one illustrated here, Midland Welding Nuts are particularly useful—eliminating the necessity of one man holding the nut while another turns the bolt into it. You can use Midland Welding Nuts advantageously in the assembly of any combination of metal stampings. May we discuss pertinent production problems with you? Write or phone us today.

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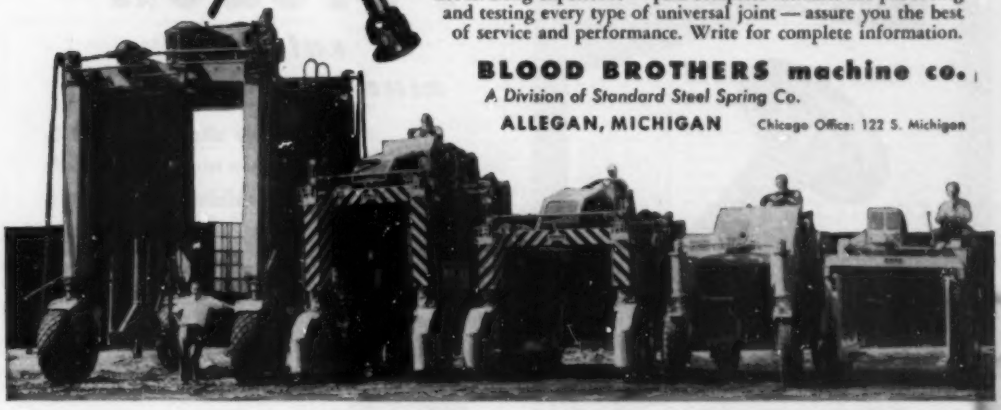
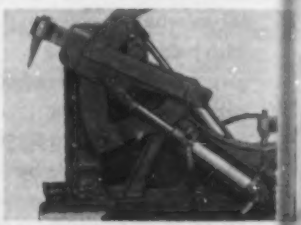


NOPAK 1-inch Manifold Valve.



Hammer Dogs are operated by 3" NOPAK Model E Air Cylinder for oscillating movement.

NOPAK Model E, 3" Air Cylinders are also used to actuate Air Boss Dogs as pictured here.

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actual size

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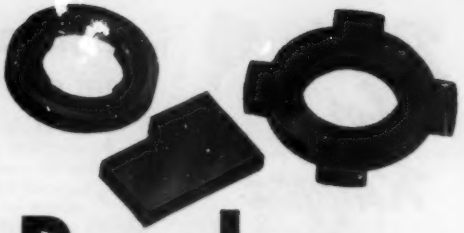

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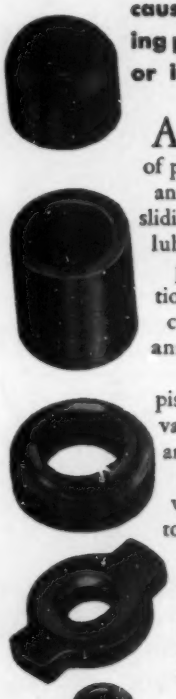

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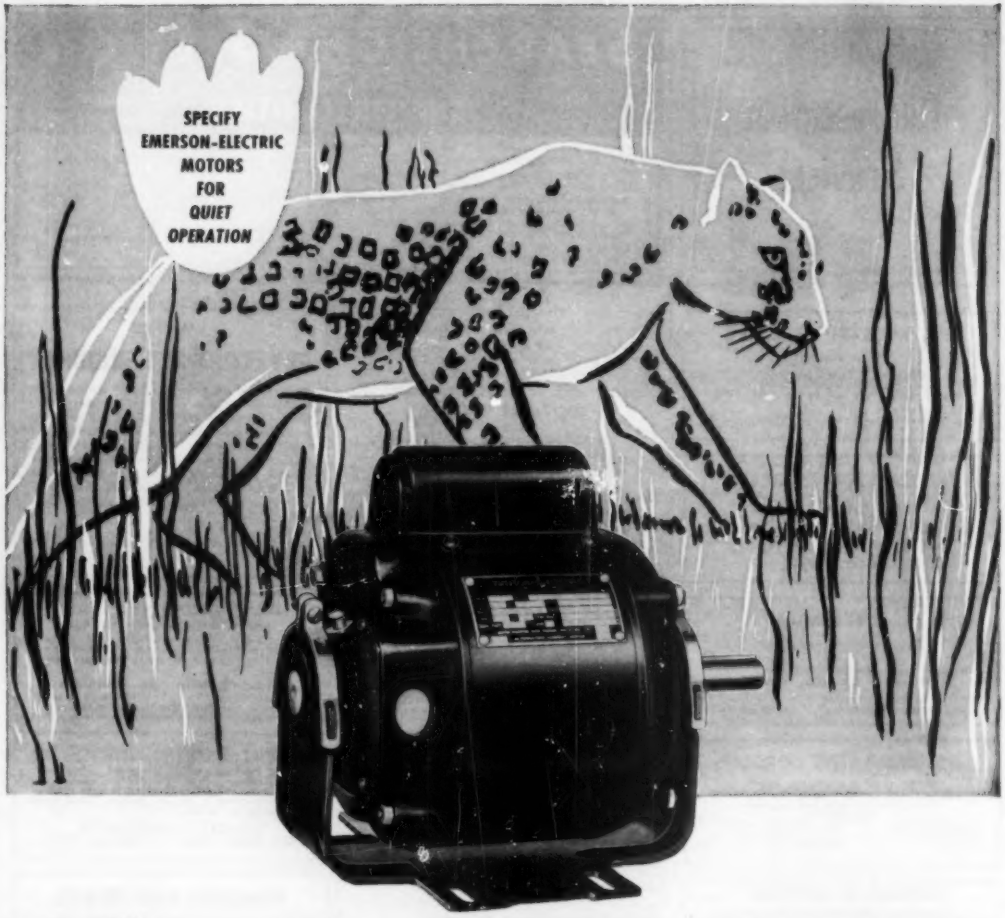

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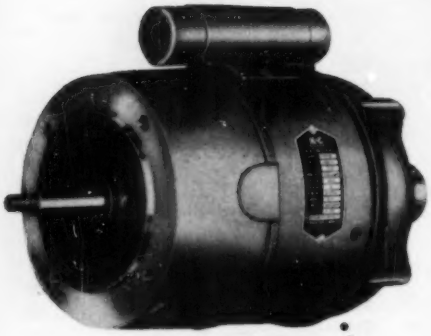
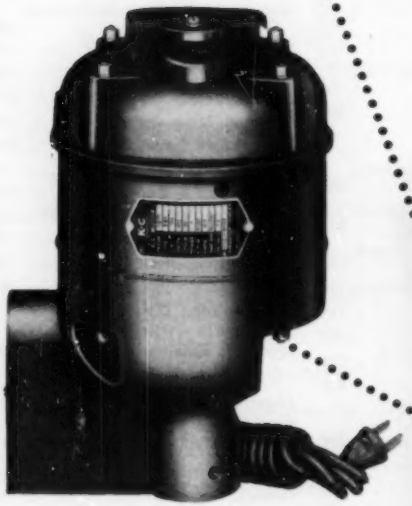
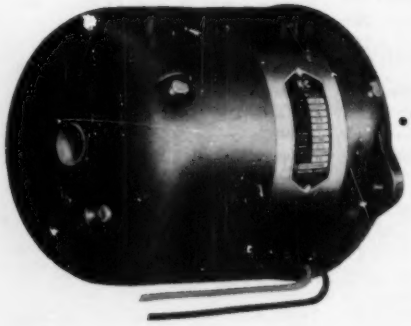
How K-C Electric Motors protect your reputation







When so much of your reputation depends on the reliability of an electric motor, you can't afford to take a chance! That's why so many design engineers specify K-C Motors to power their products.

K-C Motors are famous for long, dependable, care-free service. They run smoothly and quietly even under conditions of hard, continuous use. And, for convenience and appearance, they're compact and streamlined, handsomely styled with durable finishes.

On this page you see three types of K-C Motors. There are many others . . . so many that there's sure to be a K-C Motor to fit your requirements . . . a K-C Motor to which you can safely entrust *your* reputation. Write us for details.

K-C JET PUMP MOTORS

- Ratings of ½ through 1 H.P.
- Speed of 3450 R.P.M.
- Heavy-duty ball bearings
- Dripproof construction with or without canopy
- Both capacitor-start and three-phase designs
- Suitable for either vertical or horizontal mounting
- Automatic thermal protection on capacitor-start motors
- Temperature rise rating of 40° C. continuous

K-C SUMP PUMP MOTORS

- Ratings of ¼ and ½ H.P.
- Speed of 1725 R.P.M.
- Long-life ball bearings
- Built-in float switch
- Rigid coupling
- Automatic thermal protection
- Dripproof construction with or without canopy
- Both capacitor-start and split-phase designs
- Suitable for direct mounting on the support columns of sump pumps or cellar drains

K-C OIL BURNER MOTORS

- Ratings of ⅛ and ¼ H.P.
- Speed of 1725 R.P.M.
- Totally enclosed construction
- Manual thermal protection
- Sturdy, compact and streamlined design
- Long-life bronze sleeve bearings
- Approved by Underwriters' Laboratories

THE HOOVER COMPANY
Kingston-Conley Division
86 Brook Avenue, North Plainfield, New Jersey

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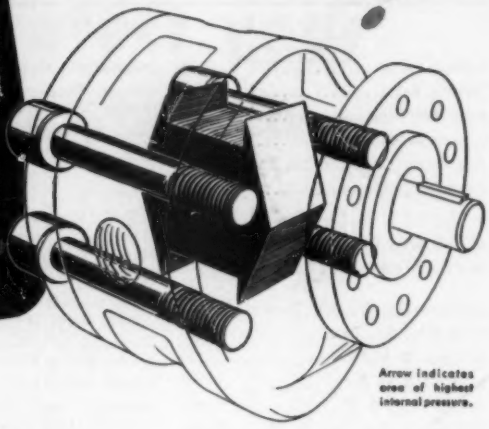
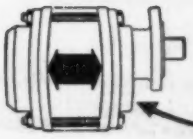
DO YOU USE *Oil Hydraulics?*

...then Investigate HYDRECO *Four Bolt* PUMPS

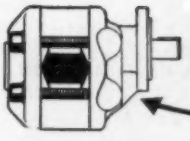


Arrow indicates area of highest internal pressure.



IN THE OLD DESIGN...

of gear pump assembly, housing parts of the pump are assembled by means of numerous bolts or studs located near the outside of the housing. There is **little support** in the pressure area. Housing parts and wear plates distort—uneven wear results and pumps quickly lose volumetric efficiency.



***HYDRECO* FOUR-BOLT DESIGN...**

locates the assembly bolts close within the area of greatest internal pressure—insuring **rigidity and stability** in design that cannot be equalled. Closer internal clearances are permanently built into the pump. There are no complicated internal mechanisms to "foul-up" from dirty oil.

***Four Bolt* PUMPS — now available in many capacities and mountings.**

HYDRECO *Four Bolt* PUMPS

Give Longer Life With Higher Efficiency

Write for Catalog and Full Information

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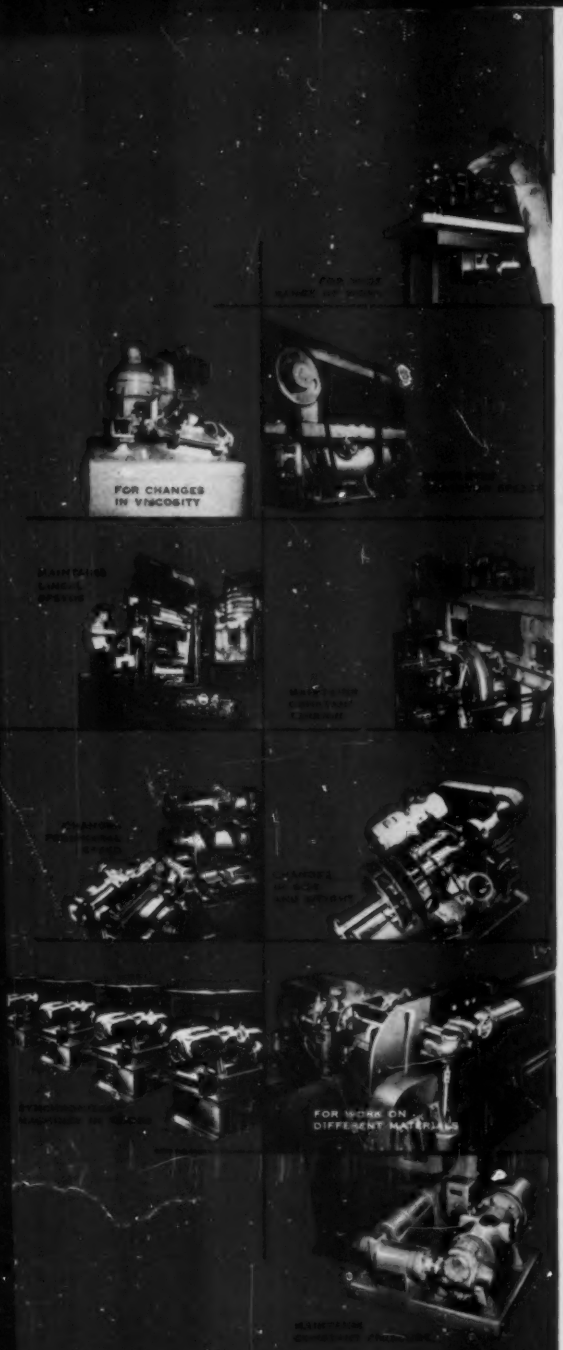
HYDRECO

HYDRAULIC CONTROL DEVICES

PUMPS · CYLINDERS · VALVES



makes a good job better

Better because variable speed operation pays off in higher rates of production, a more uniform better quality product and more efficient performance of your equipment and your operators.

And you can make the job better still by using Master Speedrangers because the all-metal construction of these variable speed drives makes them extremely compact and durable . . . more flexible and adaptable to a wide range of uses. They're available in sizes up to 5 horsepower with speed ranges up to 12 to 1 in most sizes.

Write for descriptive booklet Data 7525 and see how Master Speedrangers can help you get better results on material processing, handling and conveying equipment . . . mixers and agitators . . . machine tool drives . . . testing and calibrating equipment and many other applications.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

MASTER SPEEDRANGERS

How TIMKEN® bearings hold a spindle to its promise

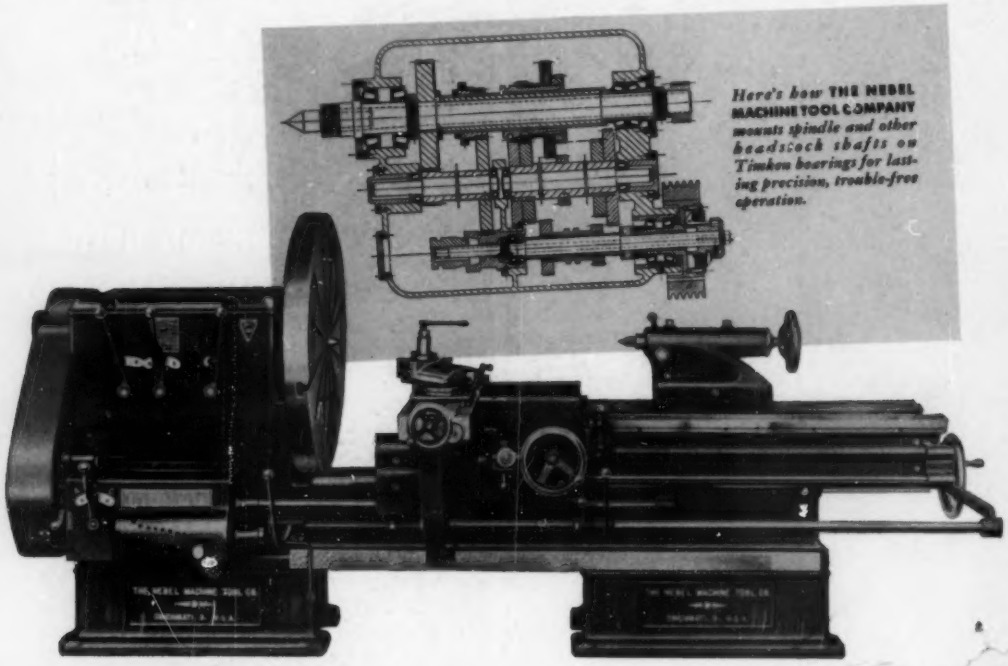
TO insure year-in, year-out precision in this extension bed gap lathe, The Nebel Machine Tool Company mounts the spindle and other headstock shafts on Timken® tapered roller bearings.

Timken bearings hold shafts in rigid alignment, keep gears meshing smoothly. The line contact between rolls and races means extra load carrying capacity. And due to their tapered construction, Timken bearings take both radial and thrust loads; minimize deflection and end-movement.

The smooth finish and true rolling motion of Timken bearings insure frictionless operation. Made of Timken fine alloy steel—best ever developed for tapered roller bearings—Timken bearings normally last the life of the machine.

Remember, no other bearing gives *all* the advantages you get with Timken bearings—backed by 50 years of bearing research and development. That's why it pays to make sure you have Timken bearings in every machine you manufacture or buy. Always look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



Here's how **THE NEBEL MACHINE TOOL COMPANY** *mounts spindle and other headstock shafts on Timken bearings for lasting precision, trouble-free operation.*

POSITIVE ROLLER ALIGNMENT

Wide area contact between roll ends and rib of the cone prevent Timken roller bearings from skewing. Result: bearings roll easier, last longer.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →✳←